

An aerial photograph of a large forest fire. The foreground is a dense, dark green forest. In the middle ground, a thick line of bright orange and yellow flames is visible, with a large plume of dark, billowing smoke rising into the sky above the fire line.

MODIS Fire Products

Chris Justice and Louis Giglio
with contributions from
David Roy, J. Owens, Jack Descloitres,
Jeff Morisette, Stefania Korontzi,
Samuel Alleaume, Francois Petitecolin, Eric Vermote

Science Rationale for the MODIS Fire Products

- **Fire is an important source of trace gas and particulate emissions**
 - radiative forcing, atmospheric chemistry
- **Fire is a proximate cause / indicator of land cover change**
- **Fire is an important biogeochemical process with a major role in the carbon and nitrogen cycles with considerable interannual variability**
- **Fire is an important ecological disturbance regime**
- **Fire is a major land management practice in tropical and temperate systems**
- **Fire frequency can be expected to change with climate change and variability**
 - Changes in extent of fire danger, fire season length
- **Fire frequency will change with human population dynamics**
- **Fire can be a natural hazard with large societal costs and impacts**
 - Need information for fire management, post-fire recovery

ESE Expected Scientific Achievements

ESE Question F2: What changes are occurring in global land cover and land use, and what are their causes?

Expected new knowledge – 5 yrs

- 1st quantitative inventory of global forest cover from Landsat
- Global inventory of land cover and analysis of land cover change based on Landsat data, establishing a basis for periodic assessments of global land cover change
- First ecological, biogeochemical cycling, and land use model simulation results incorporating actual land cover observations
- **Global inventory of fire occurrence**

Information needs for Global Change Research

Satellite Data

**MODIS
FIRE**

- Primary Fire Information (stable record over decades)
 - Location
 - Timing of fires (as an input to emissions)
 - Burned area
 - Fire intensity / energy released
 - Return frequency - time series
- Related Products (associated w. annual emission estimates)
 - Vegetation type and parameters (e.g. % tree cover, biomass)
 - Vegetation moisture content
 - Aerosol optical thickness / Aerosol characteristics
 - Distribution of traces gases e.g. CO, Tropospheric Ozone

In-situ Data

- Satellite Vicarious Calibration
 - Satellite Product Validation Data - Active fires, Burned area, others
- Data Associated with Emissions Estimation
 - Sampled Emission Factors – representative conditions
 - Sampled Fuel Loads – model validation
 - Sampled AOT – model validation
 - Ground Level Wind Speed – assimilated data

Model Output Associated with Emissions Estimation

- Modeled annual primary production > fuel load
- Modeled trace-gas and particulate emissions

MODIS Fire Products

- **MODIS 8-Day Composite Fire Product MOD14A1** Chris Justice, Louis Giglio
 - Level 3 daily, gridded (1 km) composite of the most-confident fire pixel detected in each grid cell. For convenience, eight days of data are packaged into a single file.
- **MODIS 8-Day Summary Fire Product MOD14A2** Chris Justice, Louis Giglio
 - Level 3 gridded (1 km) composite of the most-confident fire pixel detected in each grid cell over an eight-day compositing period.
- **MODIS Daily Level 2 Products (intermediate 3 month archive only)** Chris Justice, Louis Giglio
 - L2 orbit granules @ 1km
 - L2G daily per tile @ 1km
- **MODIS Global Daily Fire QA Product MOD14QA** Jacques Descloitres, Louis Giglio
 - Level 3 daily, coarse-resolution (5 km) global summary fire product indicating areas in which active fires were detected.
- **MODIS Fire Rapid Response – Daily Global Active Fires on 250m Corrected Reflectance** – Jacques Descloitres, Louis Giglio, John Owens, Chris Justice
 - Web availability within 2 –4 hours of acquisition at <http://Rapidfire.sci.gsfc.nasa.gov>
- **MODIS 0.5 Degree Climate Modeling Product MOD14CMG2** Yoram Kaufman/Charles Ichoku
 - Level 3A monthly gridded statistical summary of consolidated fire pixels intended for use in regional and global modeling
- **MODIS Burned Area Product (Experimental Regional Product)** David Roy /Chris Justice
 - Level 3 500m daily/monthly, Regional products under development – establishing provisional status prior to production

Fire Validation

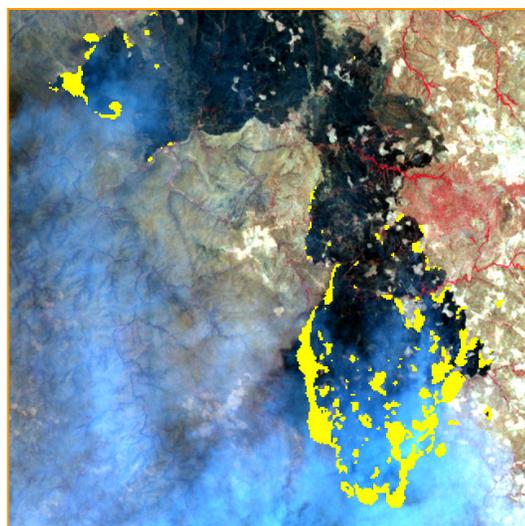
Approach

- PI Validation
- EOS Validation Program – Ward/Hao
- Broad Community Participation in Validation – Global Observation Forest Cover (GOFC-GOLD)-Fire / CEOS Land Product Validation sWG – users will then understand the limitations of the product for their particular use – the findings will be documented as a user guide to help other users

Elements

- Satellite intercomparison
 - **Global Sample ASTER / MODIS Intercomparison**
 - **Regional Validation Initiatives (CEOS LPV / GOFC Regional Fire Networks)**
 - AVHRR, DMSP, GOES, BIRD
- Controlled burns & wildfires (instrument issues)
 - **SAFARI-2000**
 - Canadian Forest Service-2002
- Field-based Product **Validation by Fire Management agencies (data access issues) using Fire Rapid Response organized through GOFC-GOLD** (2001/2002 season) - partnerships already developed in
 - USFS, Russia, Thailand, Malaya, Brazil, Indonesia, Australia, southern Africa

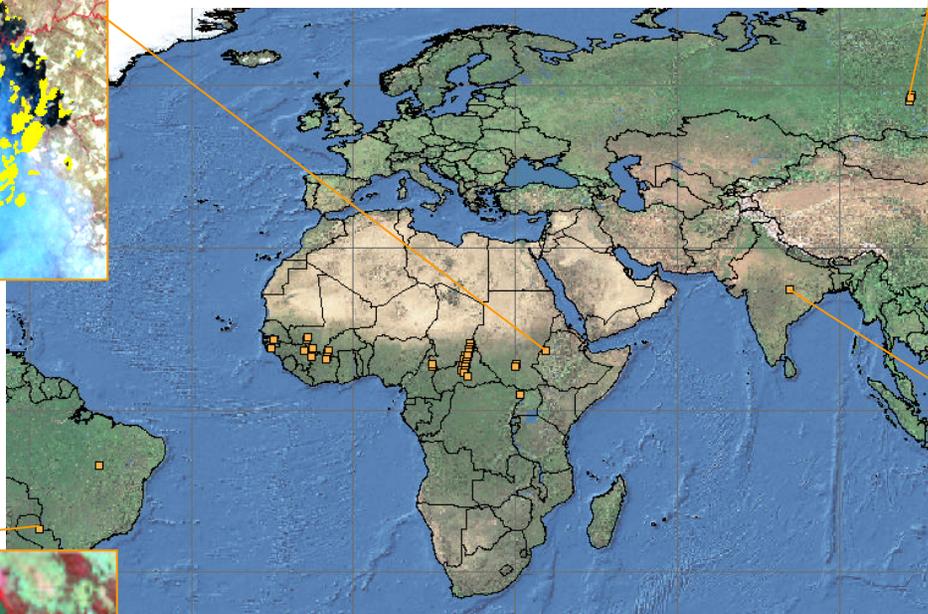
45 ASTER scenes containing fires available for comparison with MOD14



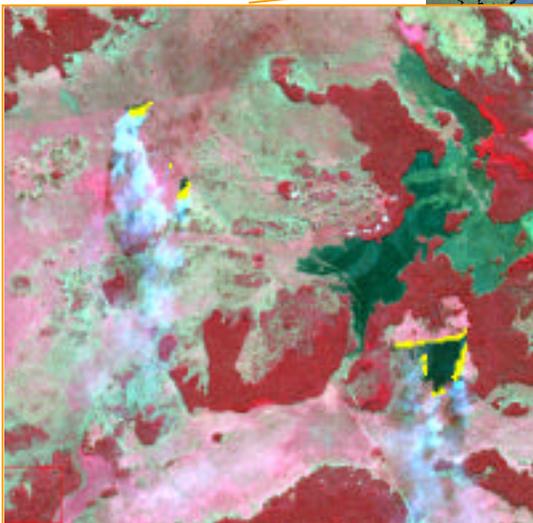
2001-03-09



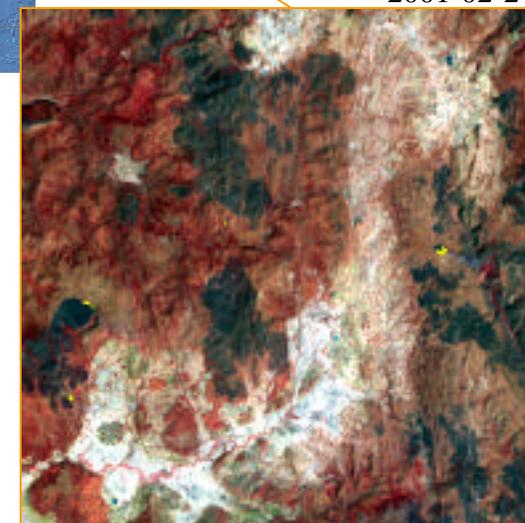
2001-05-30



2001-06-05



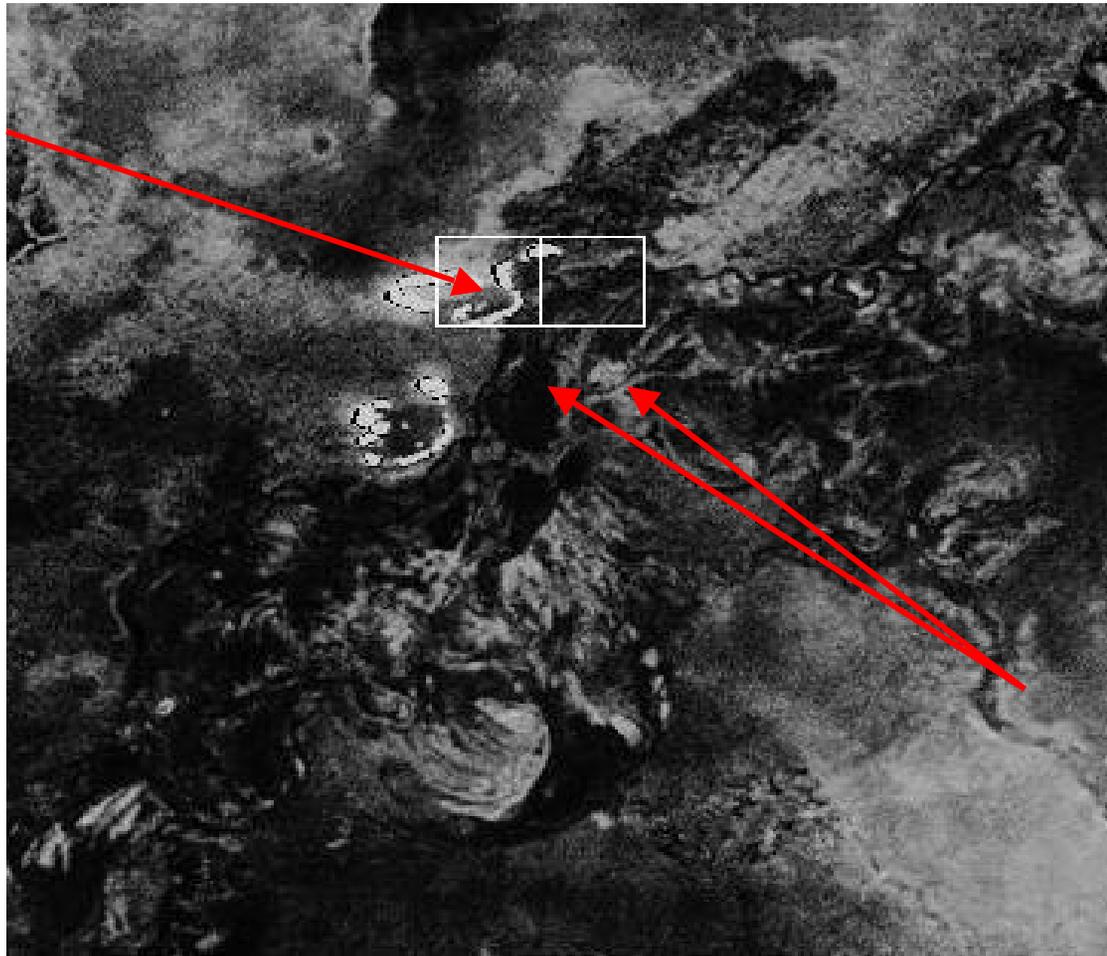
2001-02-24



ASTER composite bands 3, 2, 1
overlayed by band 9 saturated
pixels at $2.43 \mu\text{m}$ (Yellow)

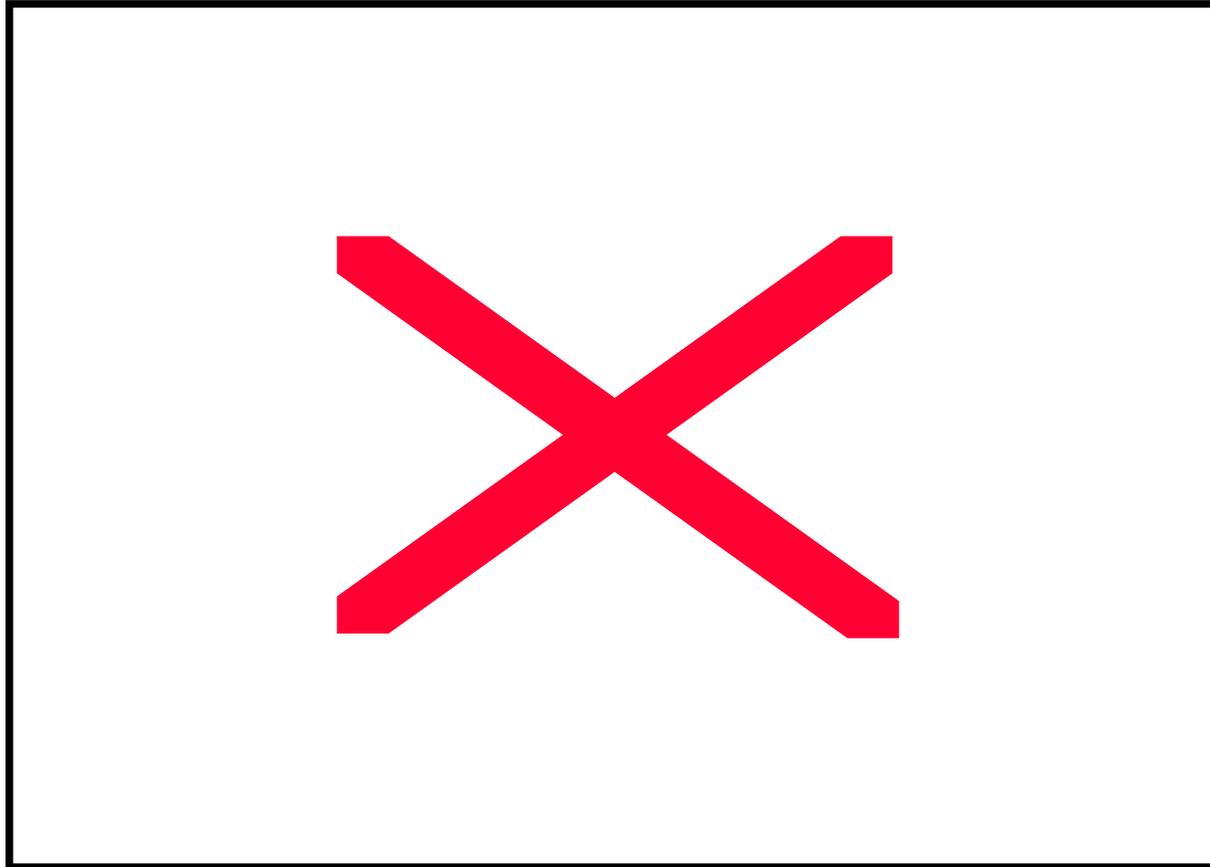
Example ASTER SWIR Scene

Active Fire
Front



1 km MODIS
Fire Product
Pixels

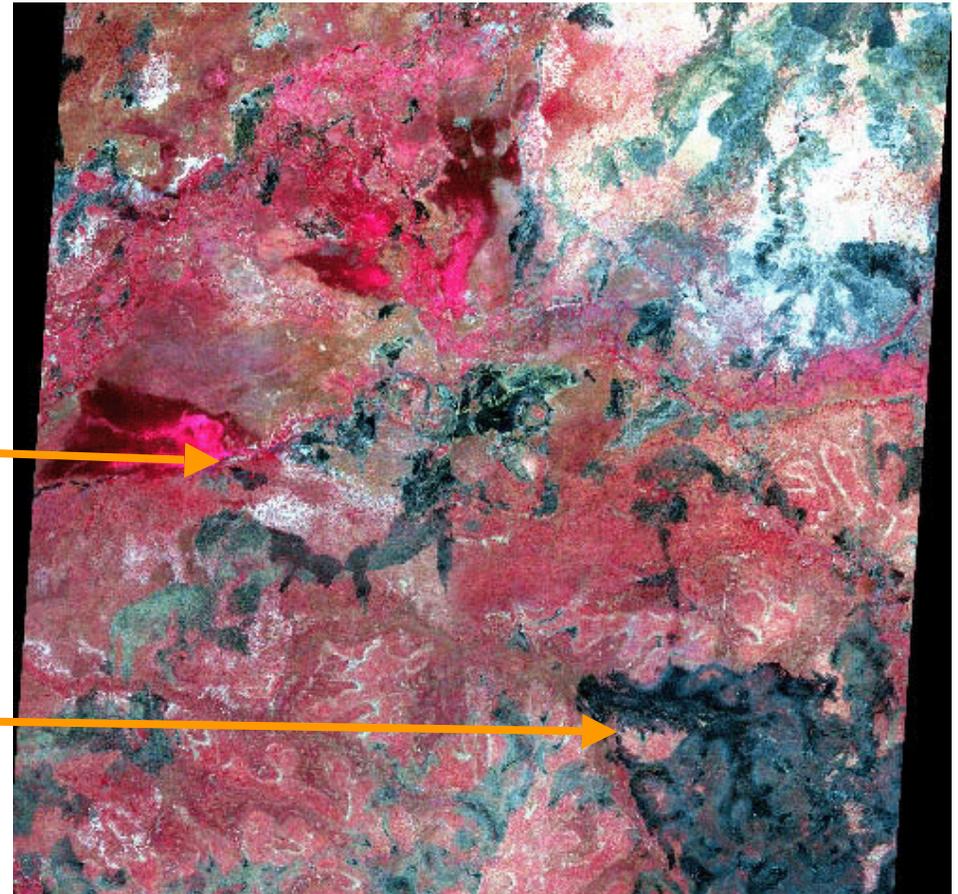
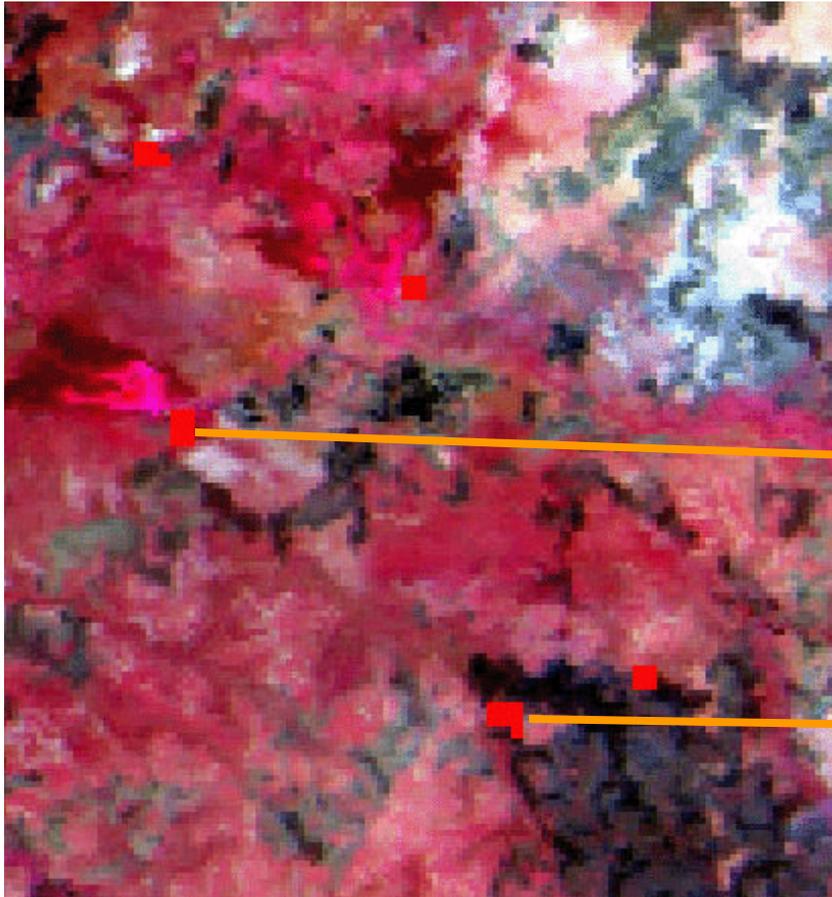
ASTER 30m Fire Detectability



ASTER will saturate over very small fires (e.g. 2m x 2m)
Simple saturation criterion can be used to identify
fires in cloud-free ASTER scenes.
Clouds will saturate ASTER fire 2.4 channel

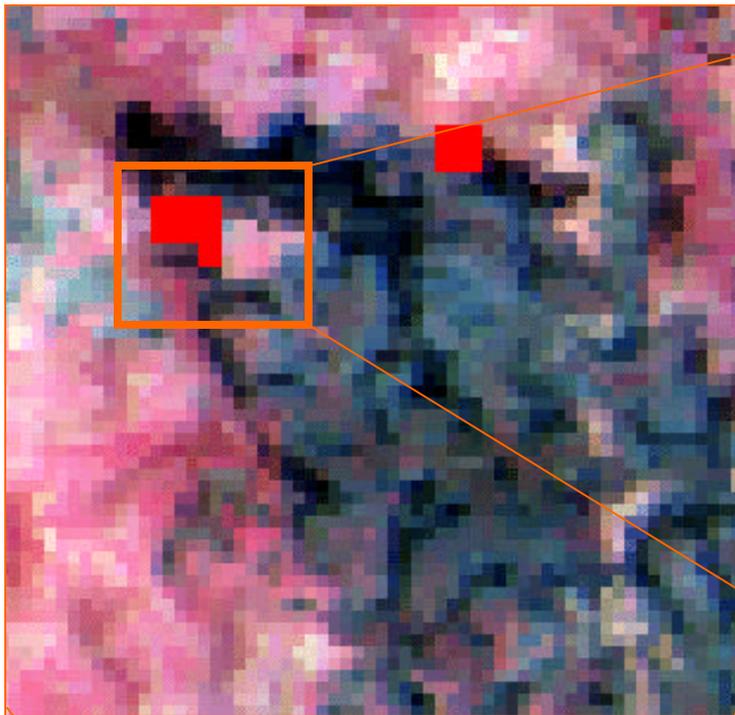
Active fire comparison between MODIS and ASTER

Terra Overpass :Nov. 23, 2000 ; 09:24:52 UT ; 9.54° Lat, 21.53° Lon

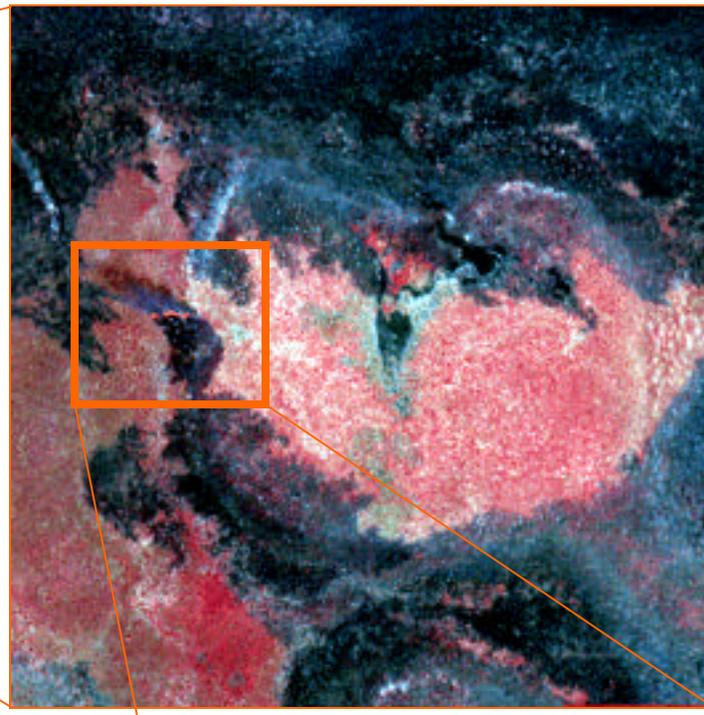


MODIS Zoom
Composite 2, 1, 4
Red dots, from Daily Fire Product MODIS (MOD14)

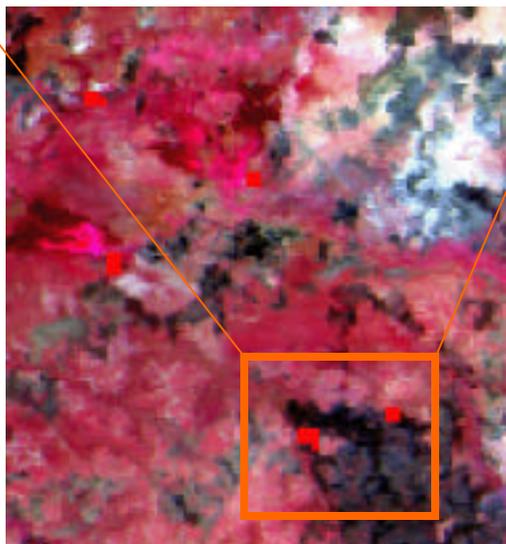
ASTER Scene
Composite 3, 2, 1



MODIS



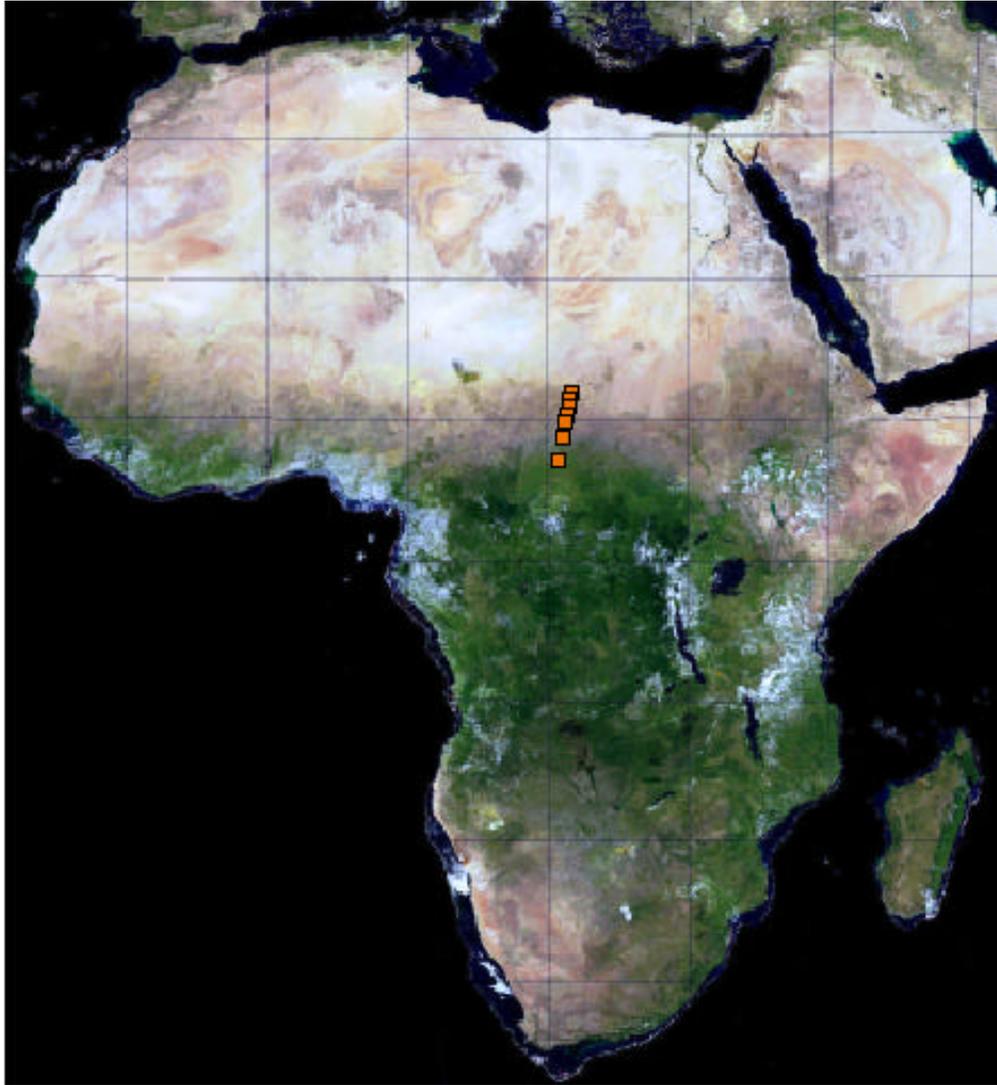
ASTER

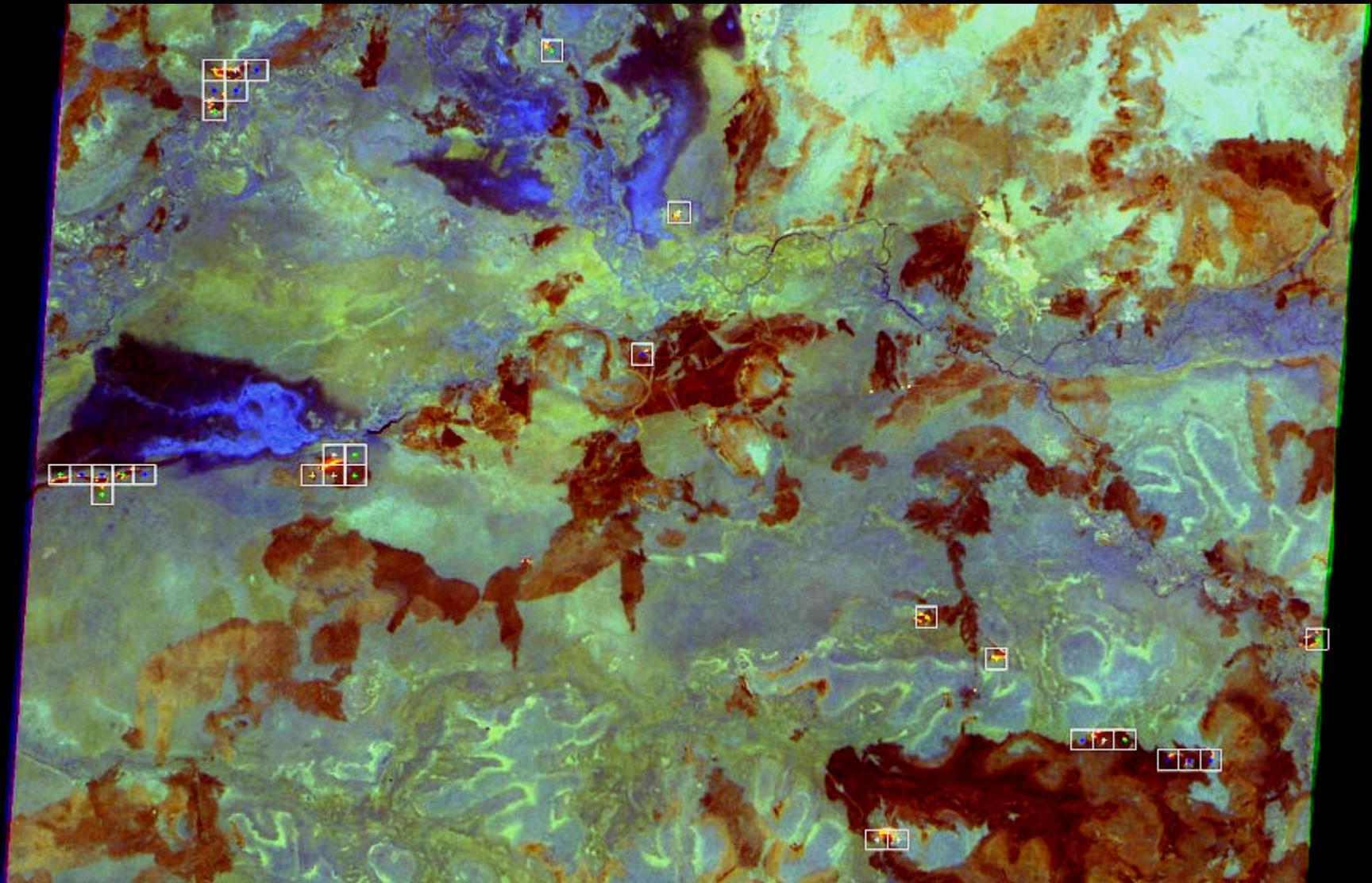


**Active
Fire
Validation**



7 ASTER scenes analyzed to date

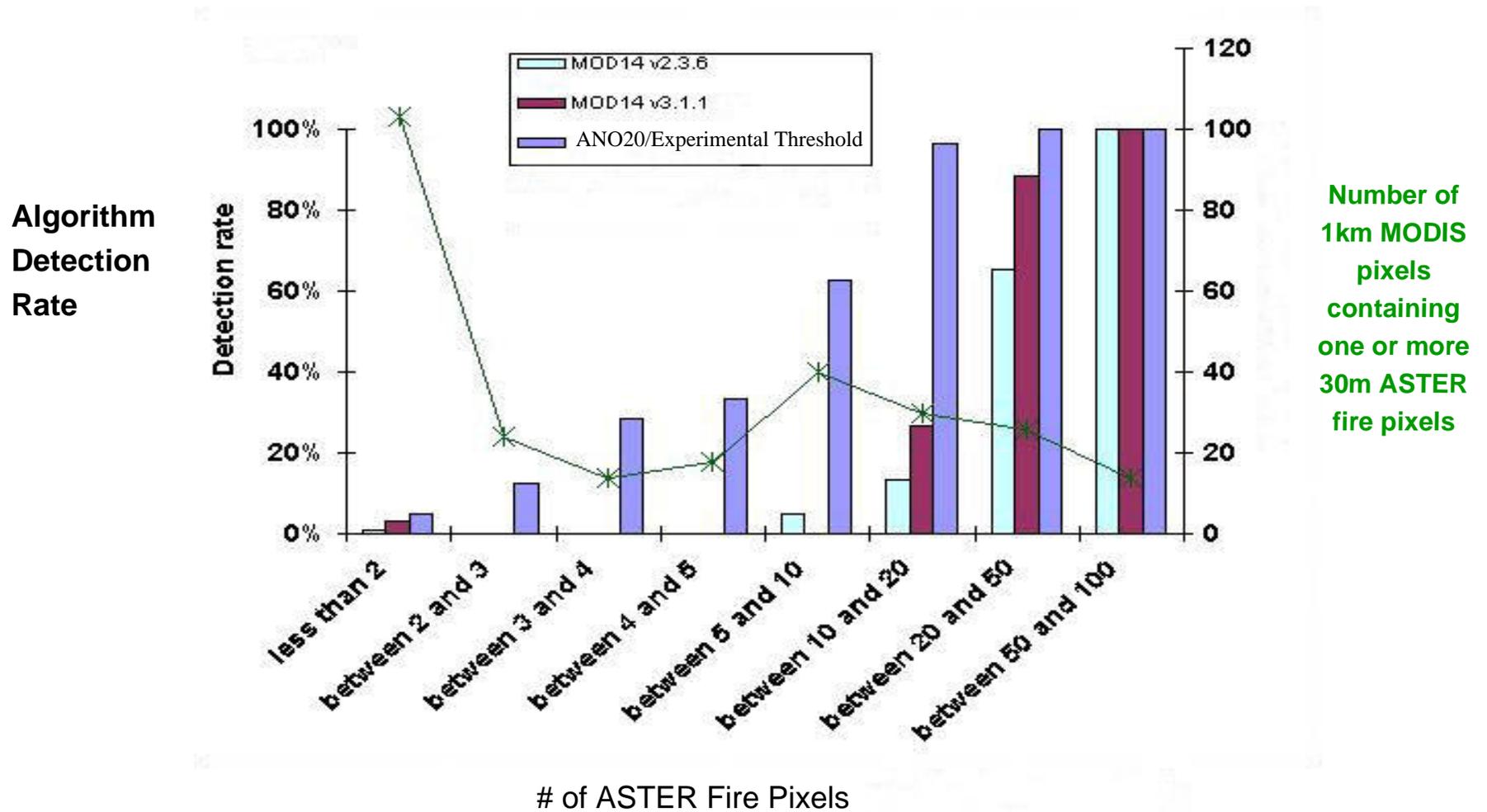




MODIS PIXELS SUPERIMPOSED ON ASTER IMAGE

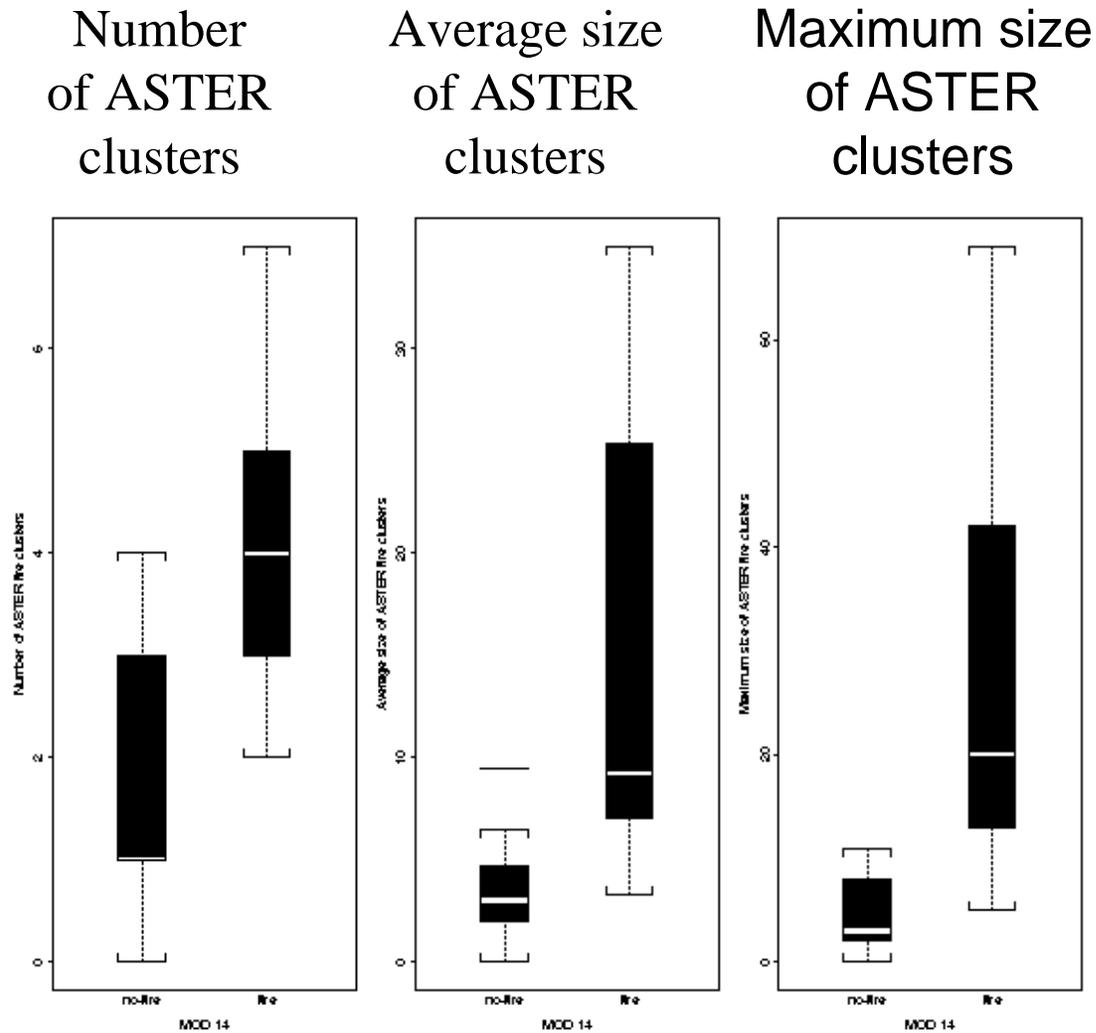
Regional Active Fire Validation

Preliminary Results - 7 ASTER scenes, Africa 2000



MODIS /ASTER Comparison

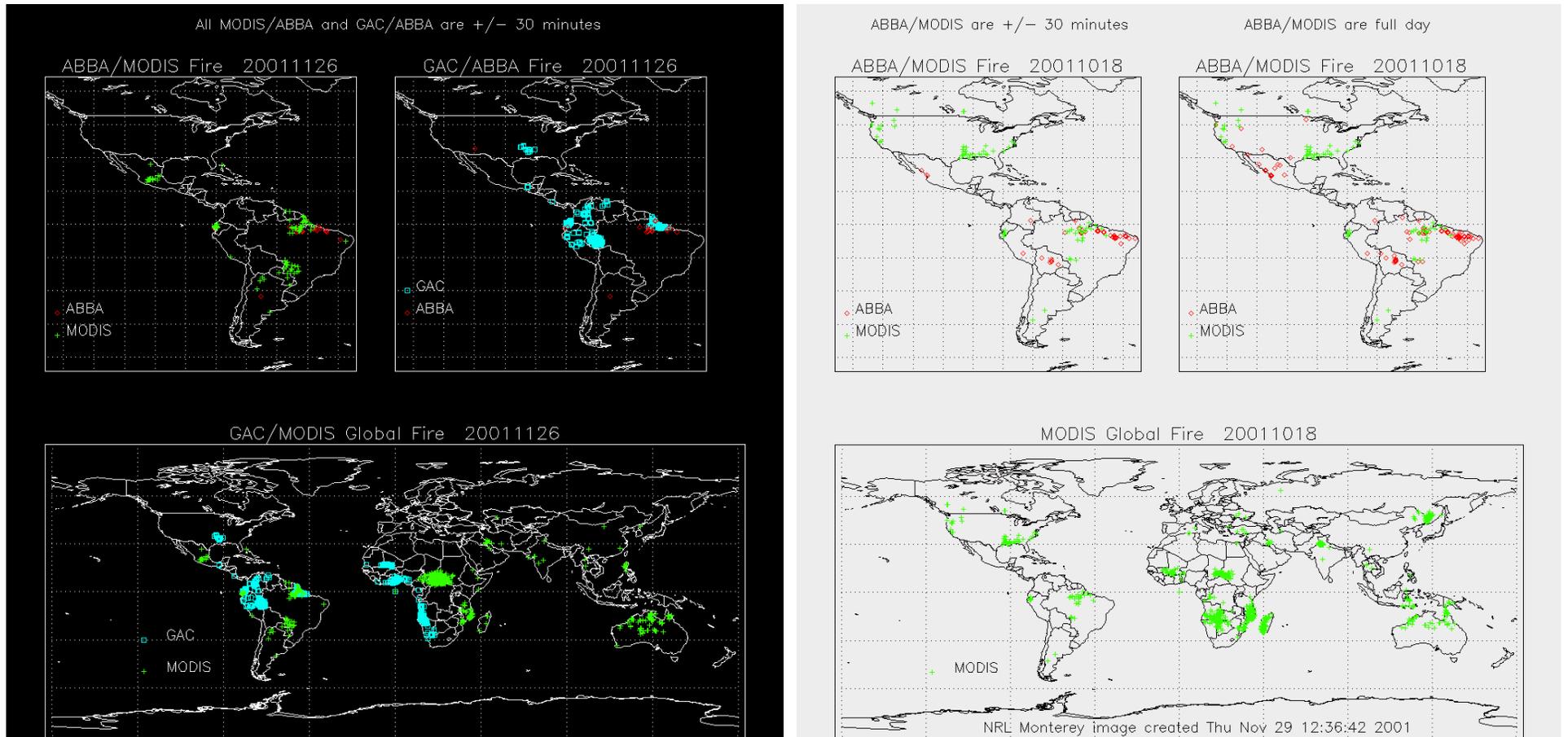
ASTER fire cluster (contiguous pixels) statistics



Left Column: MODIS non-fire pixels

Right Column: MODIS fire pixels

MODIS/GOES Active Fire Comparison



D. Westphal, K. Richardson,
Naval Res. Lab, Monterey

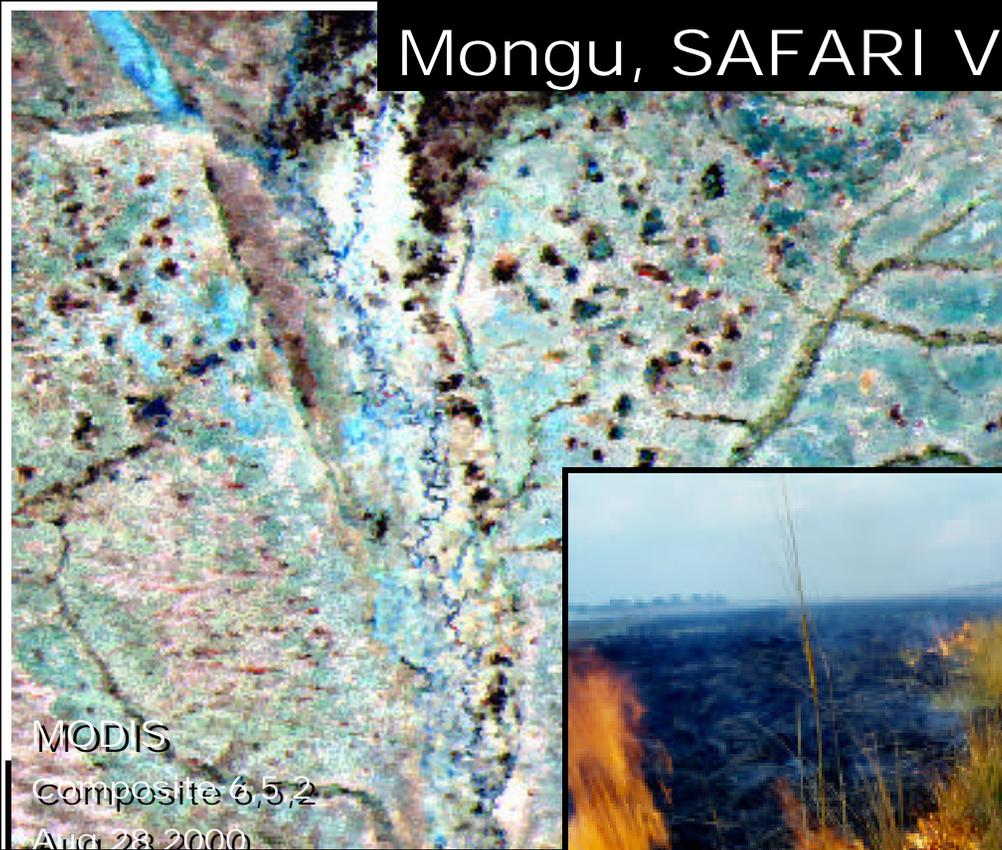
Red – GOES ABBA
Green – MODIS
Blue – AVHRR GAC

MODIS Fire Validation: SAFARI 2000

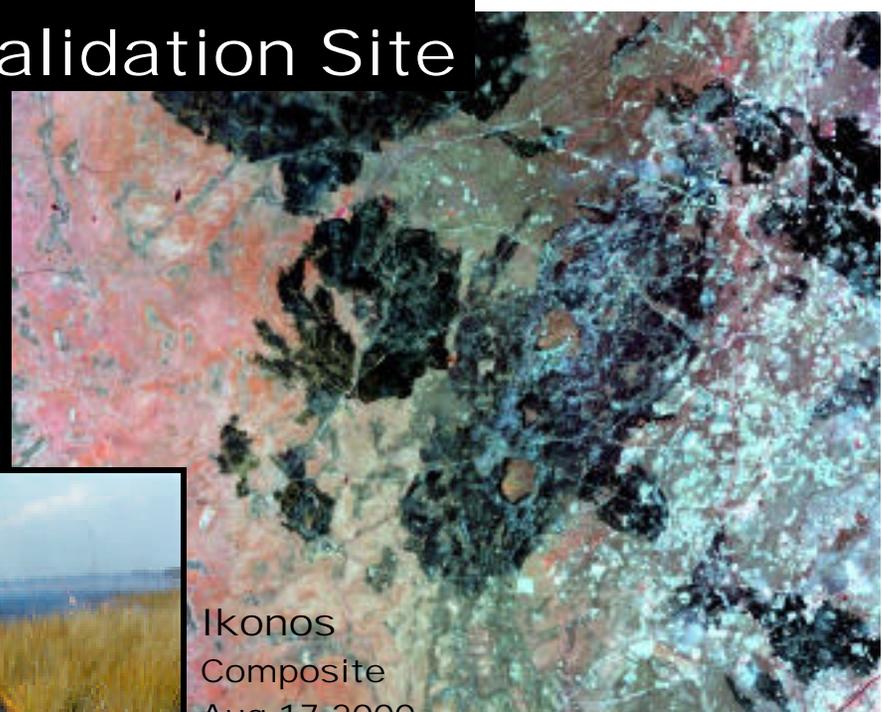
(Justice/Giglio/Roy et al.)

- **Active Fire Product**
 - comparison with AVHRR SAFARI fire fields (GIMMS)
 - ASTER acquisitions for SAFARI sites (Mongu / Skukuza)
 - MAS fires of opportunity during SAFARI intensive (Aug/Sept 2000)
- **Ward/Hao (Validation Scientist) – SAFARI fire activity -TBD**
- **Burned Area Experimental Product (Emissions Driven Agenda)**
 - Landsat burn scar mapping as a validation for MODIS product
 - Burned area validation sites selected Zambia, South Africa, Zimbabwe, Mozambique, Botswana, Namibia, Malawi
 - In-country collaborations formulated through MIOMBO Network Fire Group to participate in Landsat 7 scar assessment and MODIS product evaluation
 - Field protocol development in late June (Zambia, Zimbabwe)
 - Validation intensive (August – September)
 - Results meeting – 2001 & 2002
- **International coordination – SAFNET**
 - GOFC Fire Validation Workshop, March 2000 – GOFC Fire validation

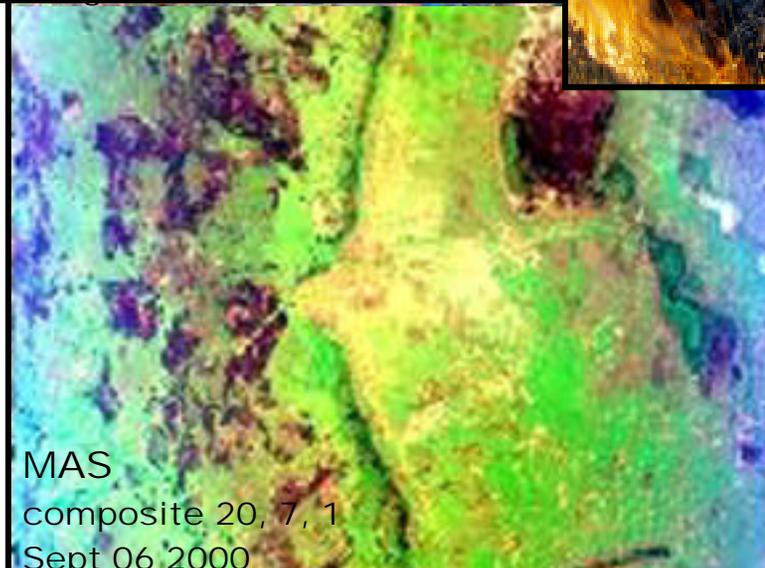
Mongu, SAFARI Validation Site



MODIS
Composite 6,5,2
Aug 28 2000



Ikonos
Composite
Aug 17 2000

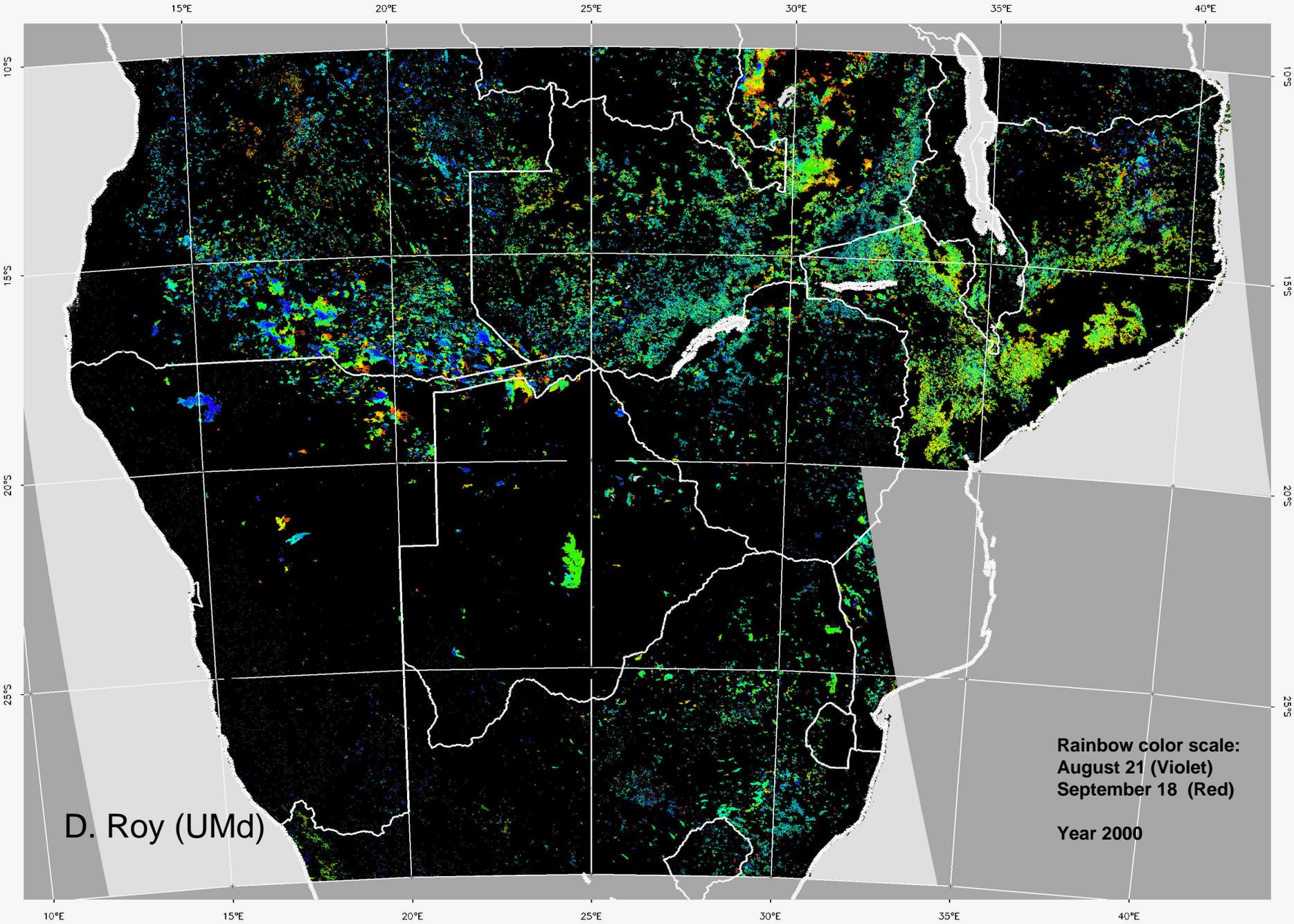


MAS
composite 20, 7, 1
Sept 06 2000

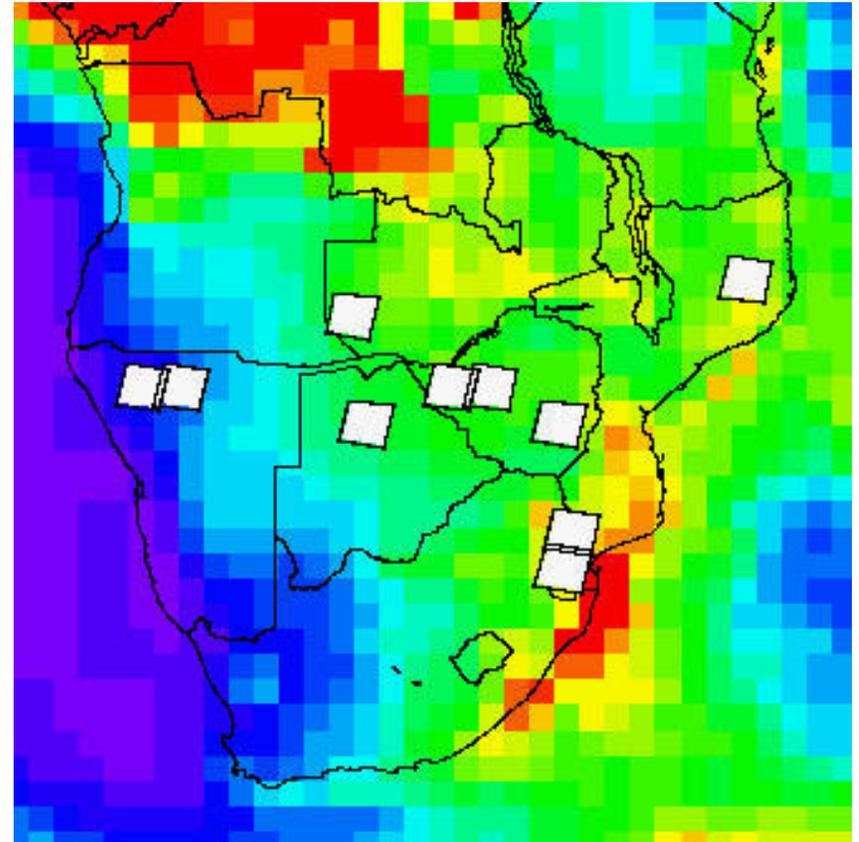


Landsat 7
composite 5, 4, 3
1st Sept 2000

Regional MODIS burned area map showing date and location at 500m of burning



Burned area validation sites, Landsat ETM+ path/rows
(distributed from dry savanna to wet miombo woodland to quantify product accuracy
over range of representative biomass burning conditions)



MODIS 1km land cover product

2000 annual precipitation

derived from TRMM 1° data

(blue < 300mm, red > 1500mm)

D. Roy (UMd)

Validation of MODIS 500m burned area product



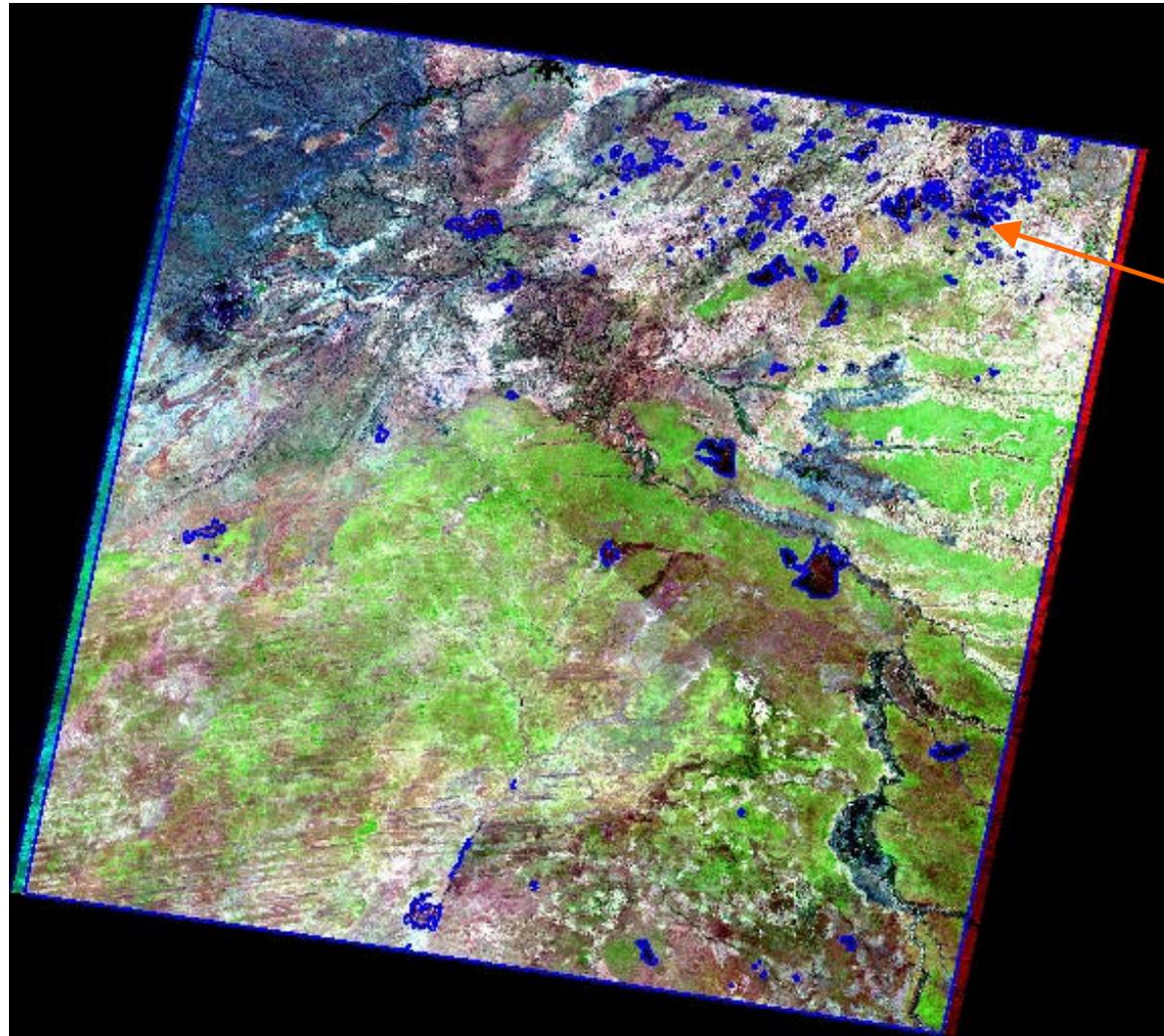
Landsat ETM+ burned area maps, compiled by collaborators across Southern Africa, using multi-temporal Landsat data.

Consensus mapping protocol developed during a traveling meeting, Zimbabwe-Zambia 11-19th July 2000.



Example burned area interpretation: *Matabeleland Central Forest District, Zimbabwe*

Burned areas (**blue vectors**) mapped between Landsat acquisitions 8/27/00 and 9/28/00 superimposed on 9/28/00 Landsat false color image

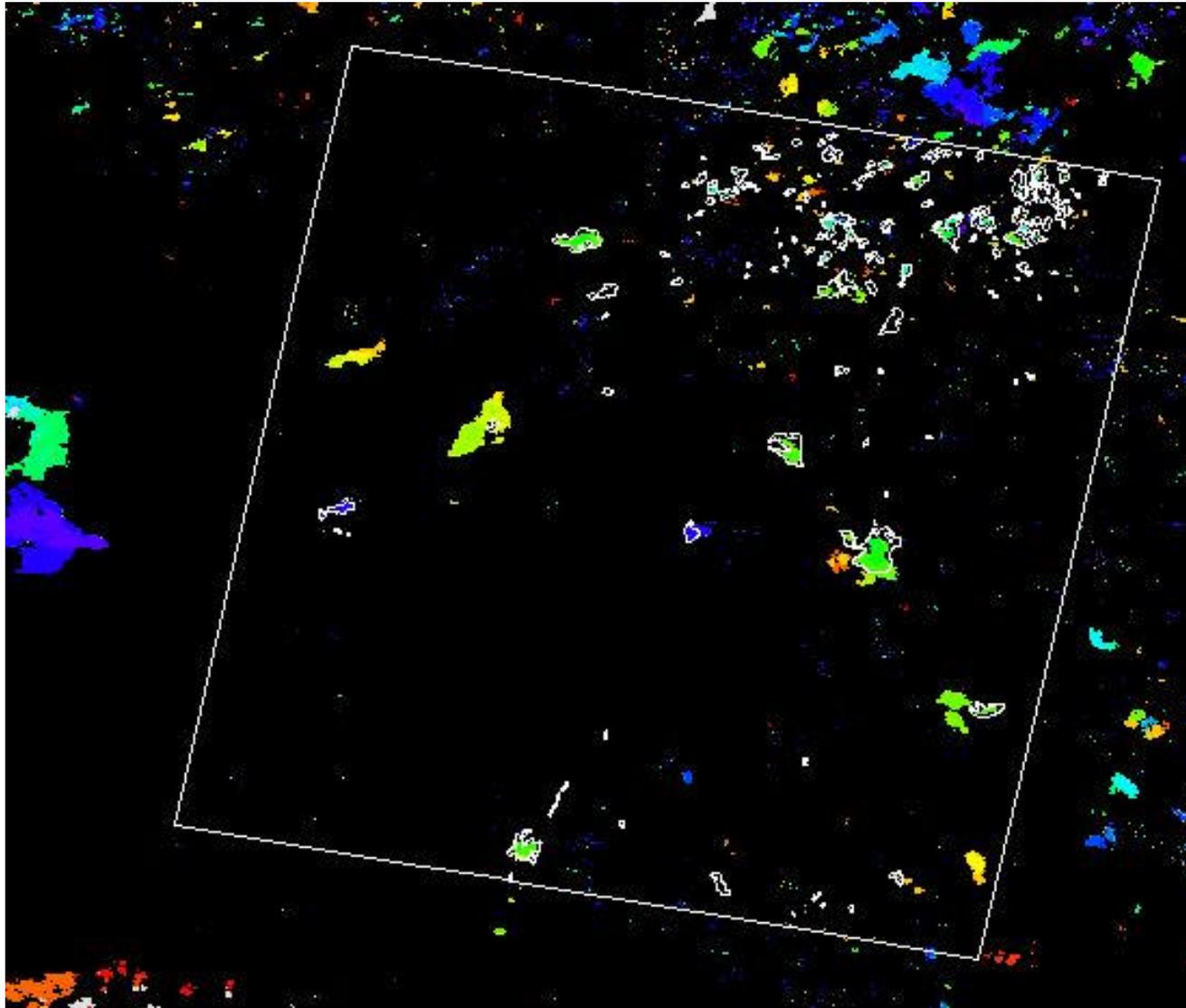


Fragmented and small burned areas on communal land

Mapped by
collaborator
Kolethi Gumbo
(Zimbabwe
Forestry
Commission)

D. Roy
UMd

Landsat interpretation showing burns occurring 8/27/00 - 9/28/00 (white vectors) superimposed on MODIS 500m burned areas (colors)

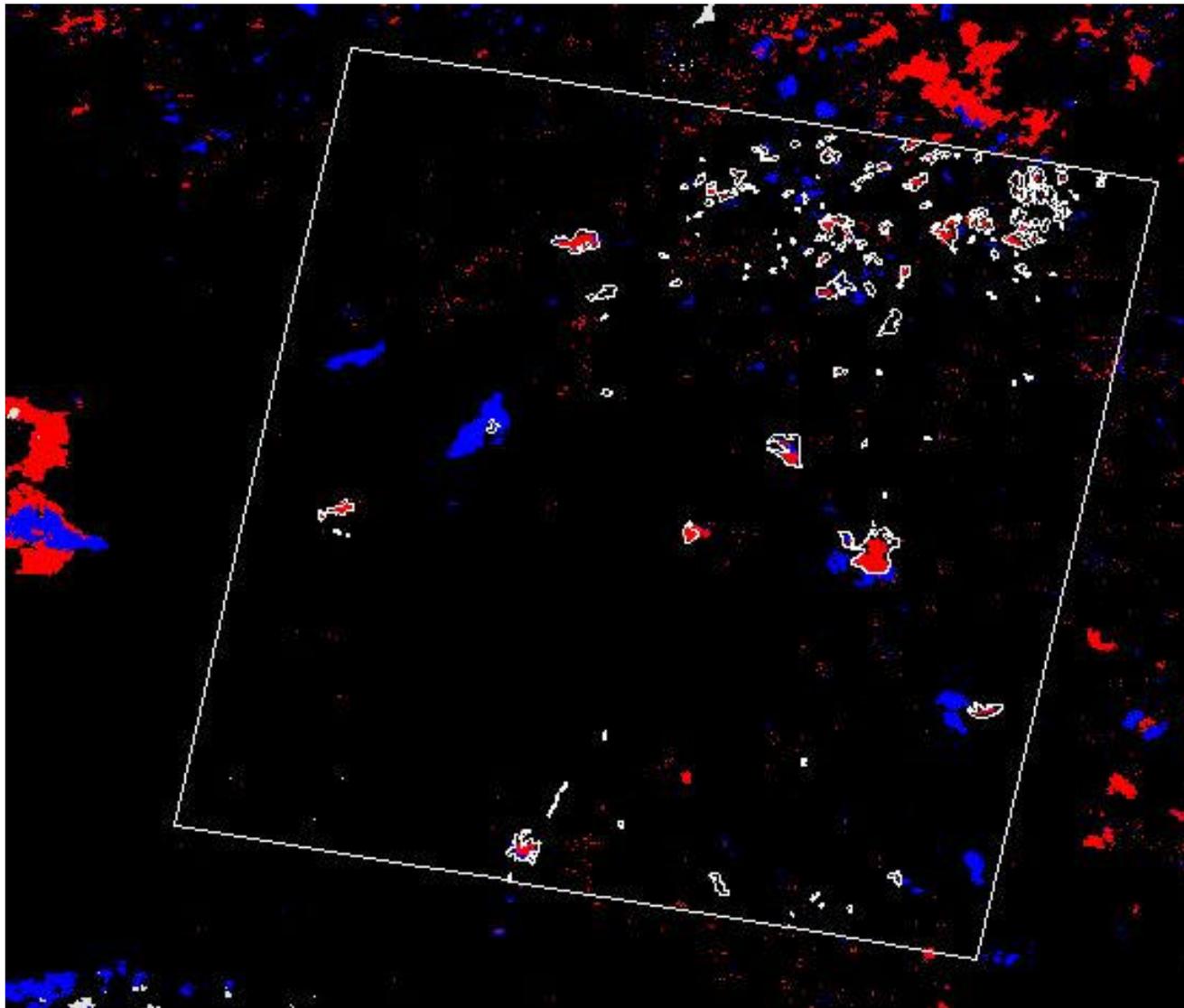


D. Roy
UMd

Red = MODIS burned areas detected in Landsat acquisition period 8/27/00 - 9/28/00

Blue = MODIS burned areas detected before or after 8/27/00 - 9/28/00

White vectors = Landsat interpretation showing burns occurring 8/27/00 - 9/28/00



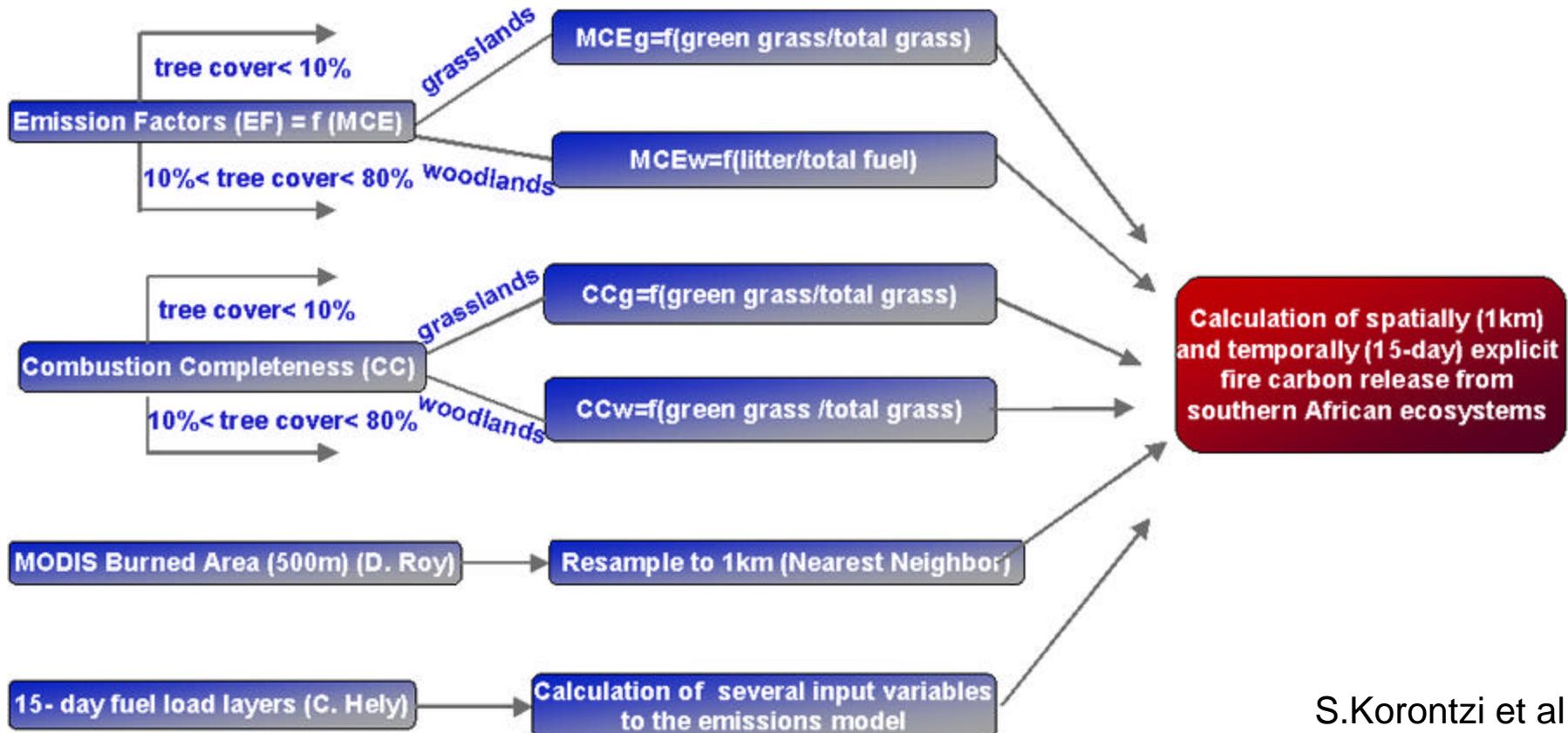
D. Roy
UMd



Modeling pyrogenic emissions over southern Africa using MODIS burned area information



FIRE EMISSIONS MODEL OUTLINE



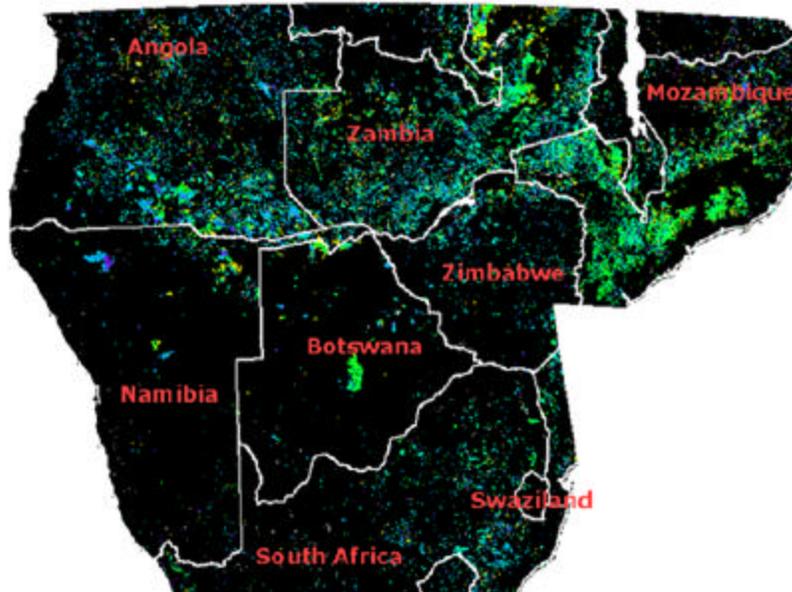


Modeling pyrogenic emissions over southern Africa using MODIS burned area information

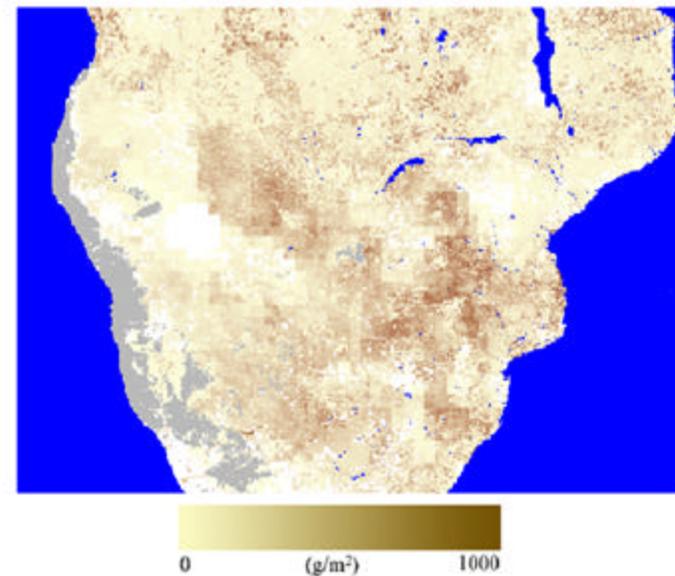


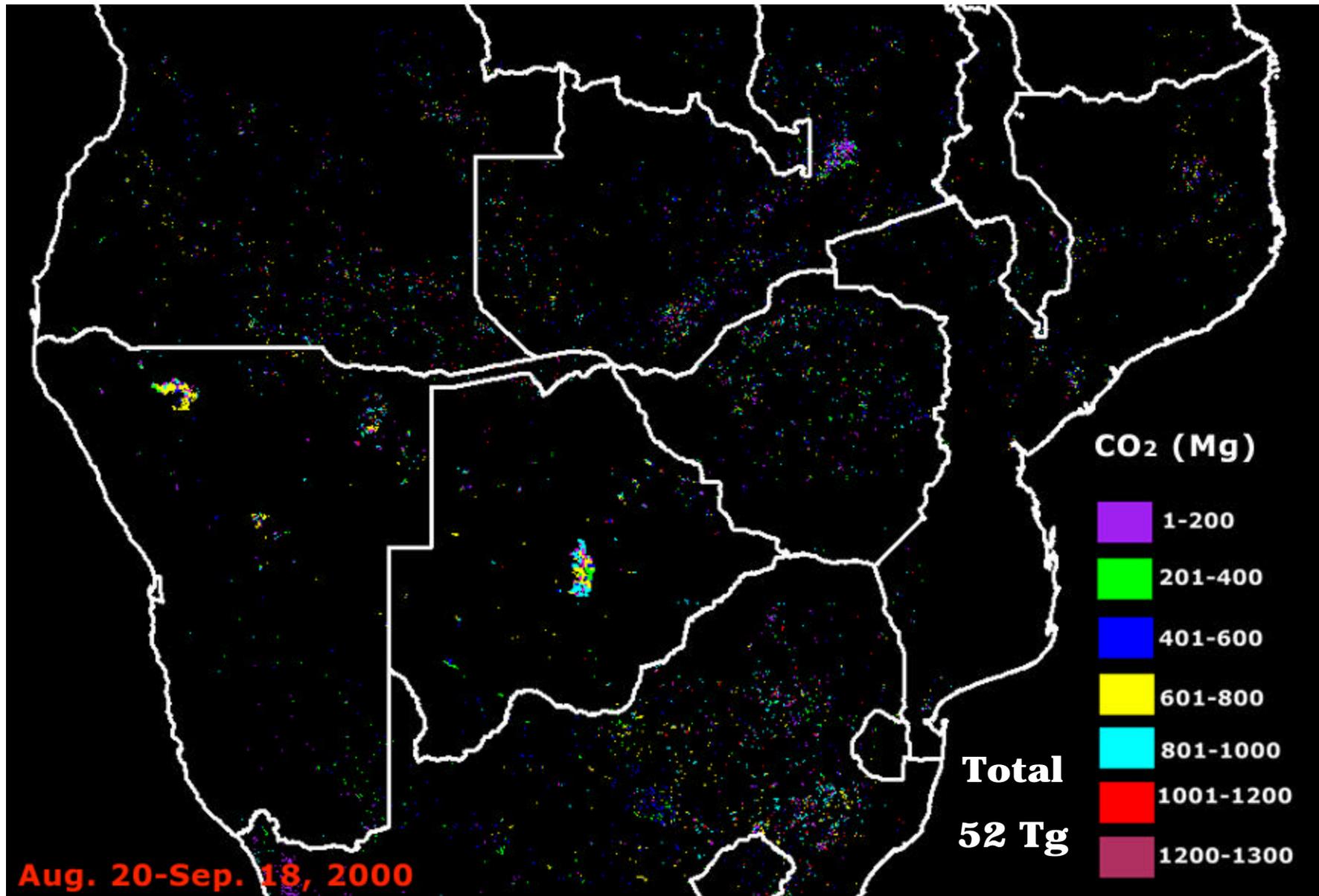
SELECTED MODEL INPUTS

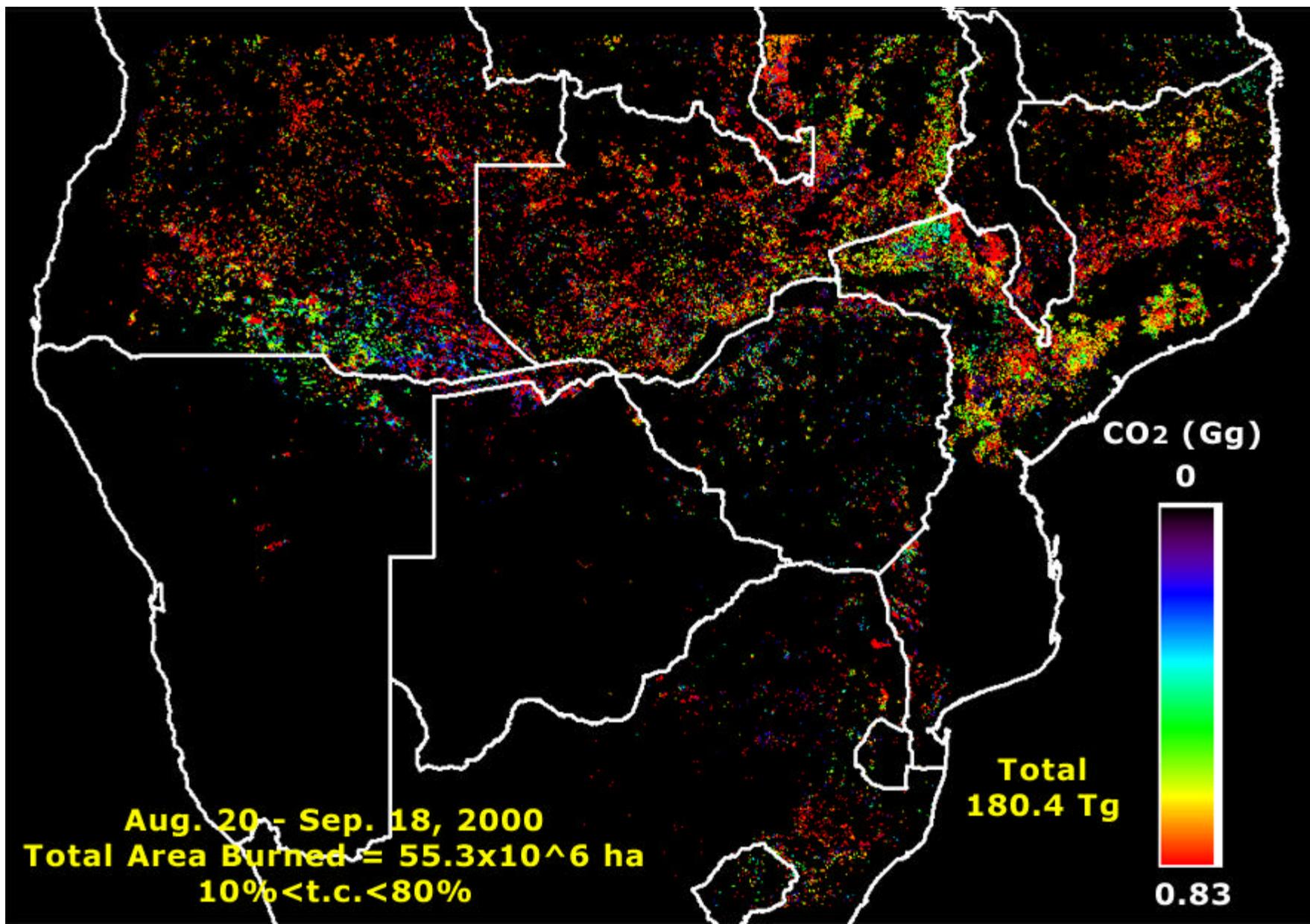
**MODIS Burned Area Prototype 500m
Aug. 20-Sep. 23, 2000**

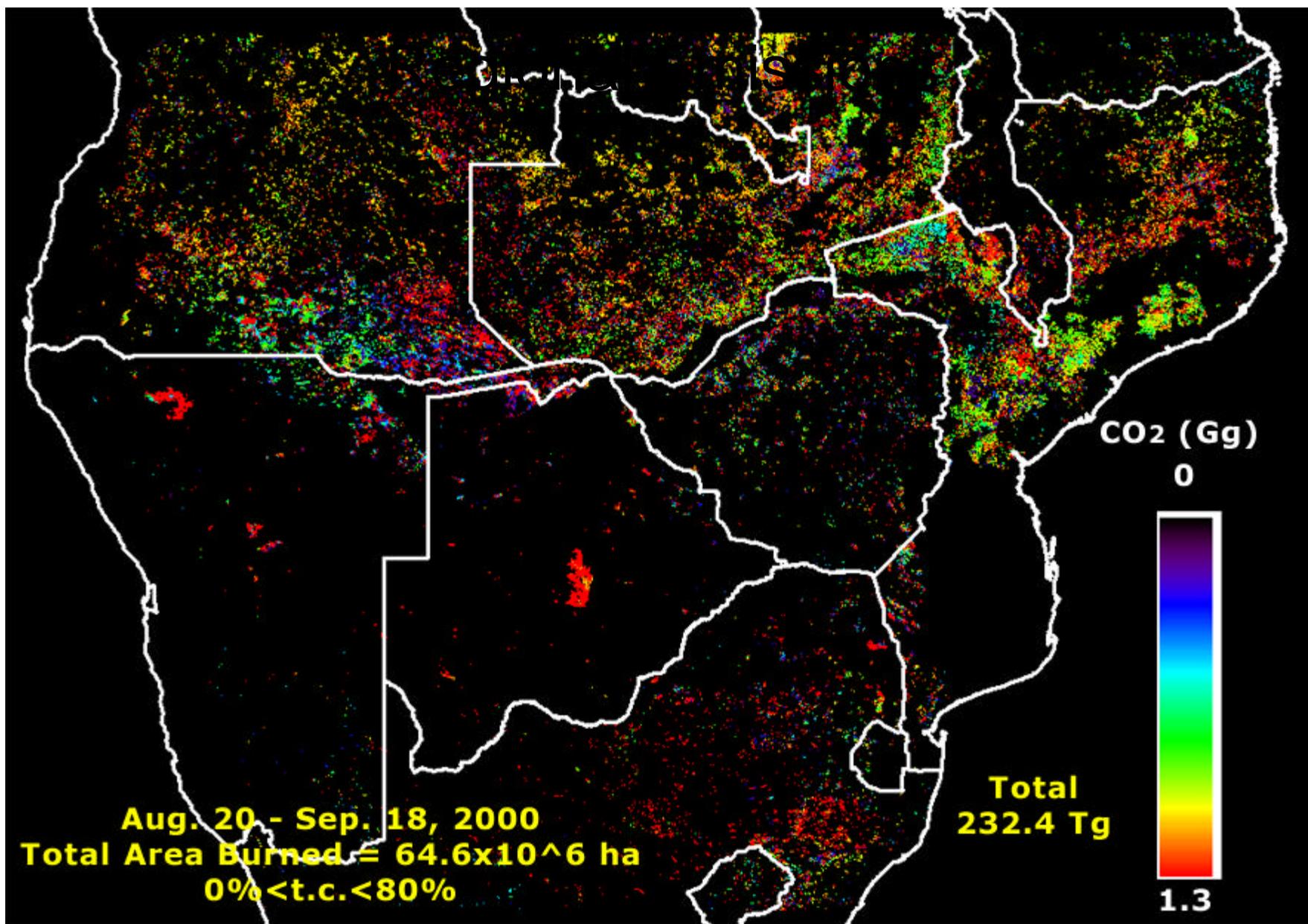


**Dead Grass Fuel Load (1 km)
August 30, 2000**



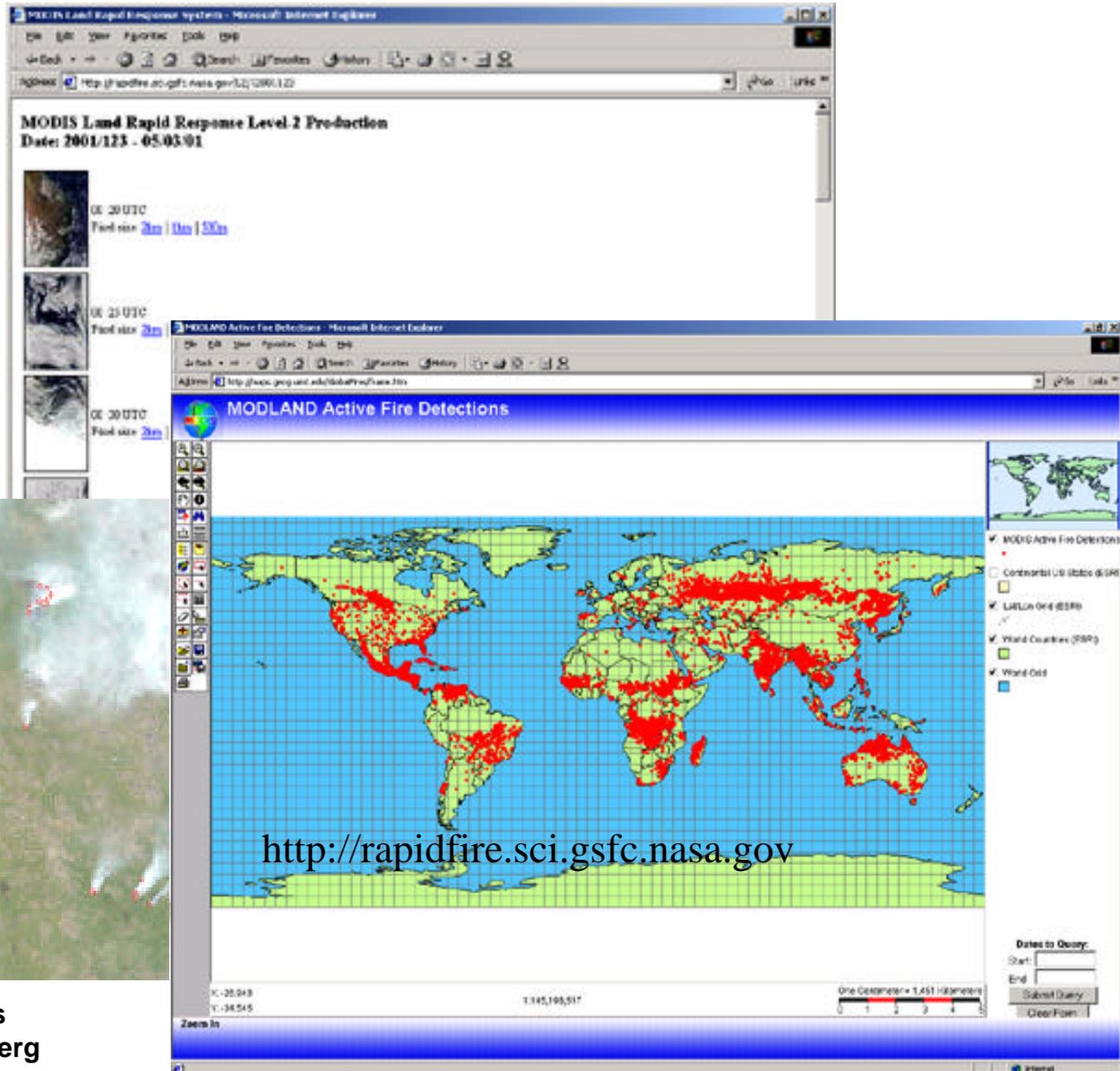






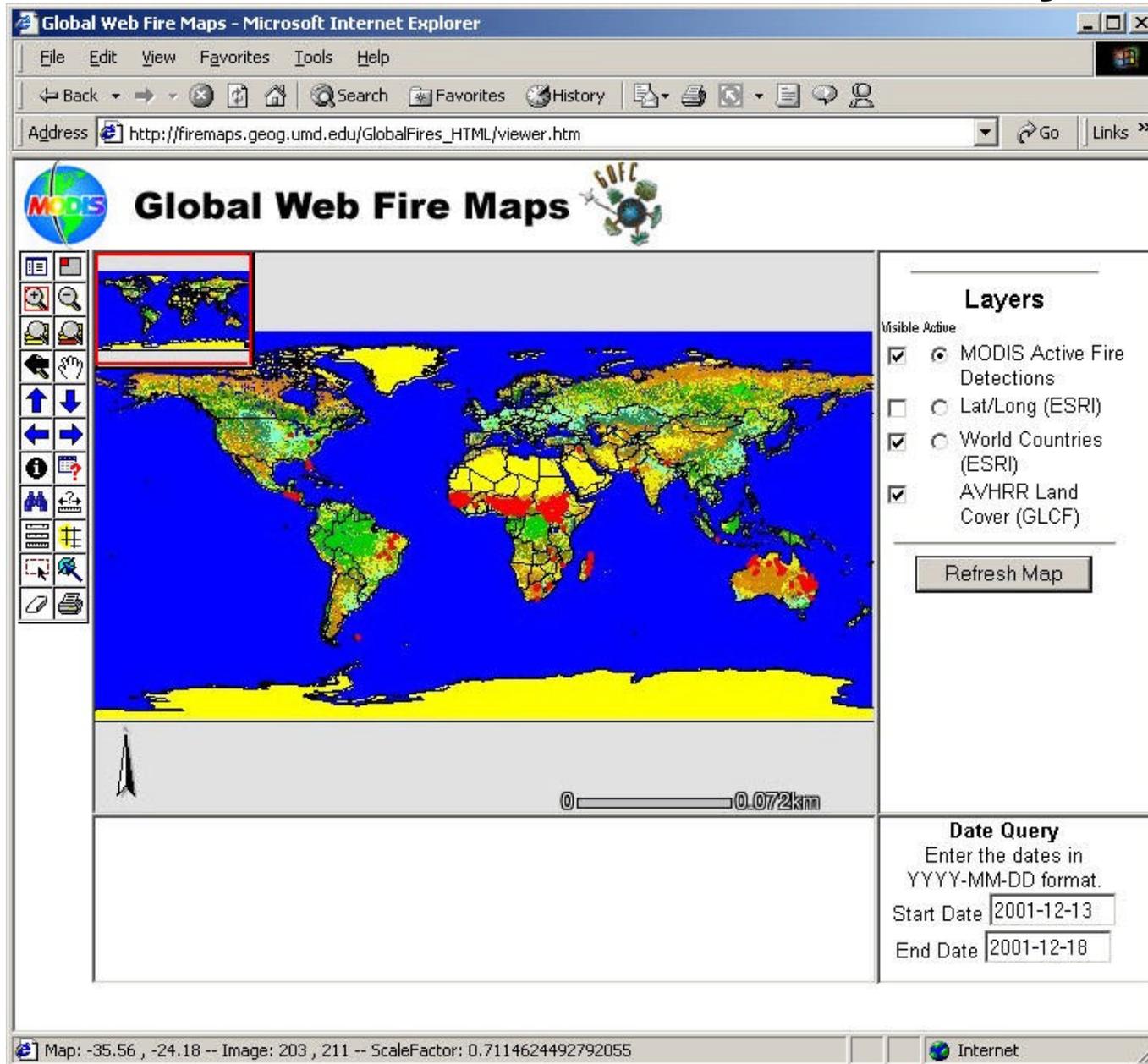
NASA MODIS Fire Rapid Response Data System

Daily global coverage with a 2~4 hour delay producing and distributing global fire detections and RGB imagery via the Internet using FTP and ArcIMS feature server



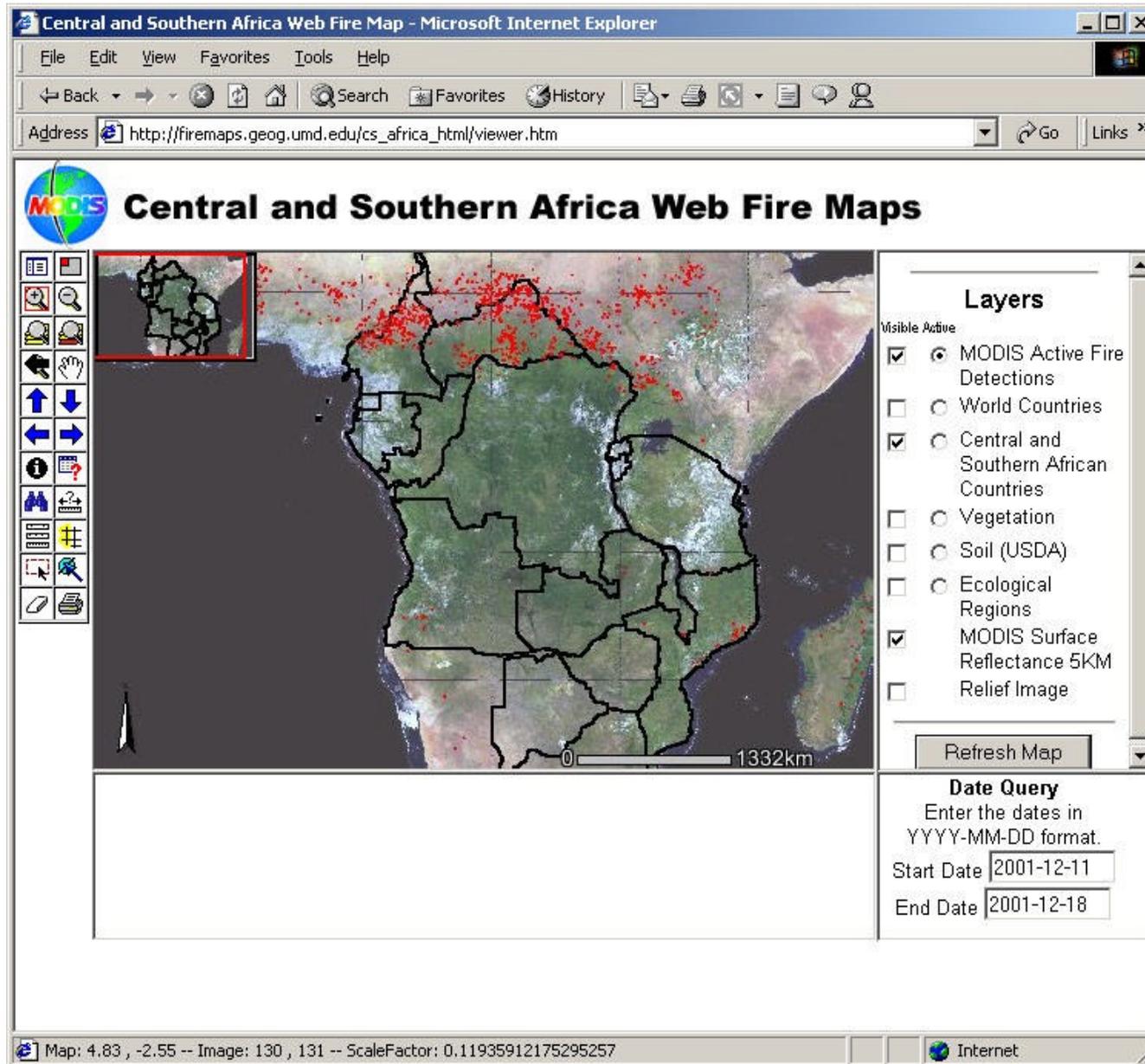
J. Descloitres, L. Giglio, J. Owens
J. Seaton, M. Crisologo, R. Sohlberg

Global fires from the last 5 days



MODIS
Fire
WEB/GIS
J. Owens
M. Crisologo
UMd

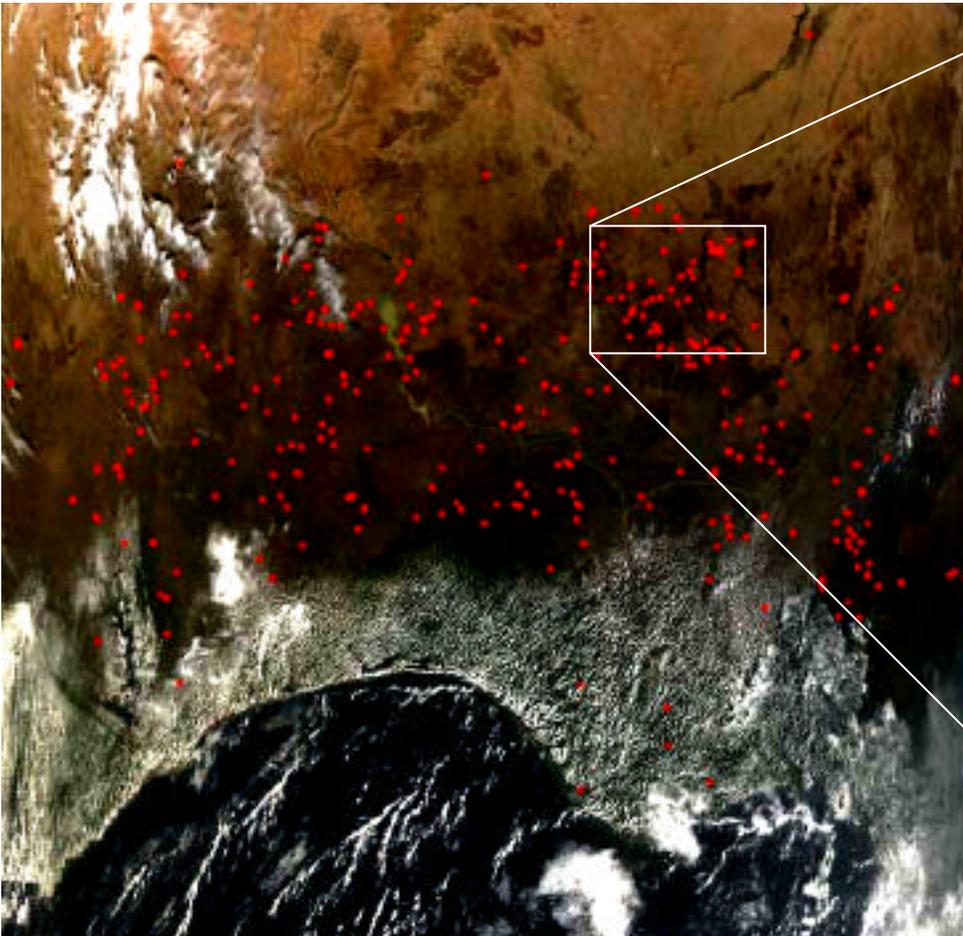
Active Fires in W. Africa, Dec 11-18 2001



MODIS
Fire
WEB/GIS
J. Owens
M. Crisologo
UMd

Rapid Response Today's Fires

W. Africa S. Mali /N Cote d'Ivoire

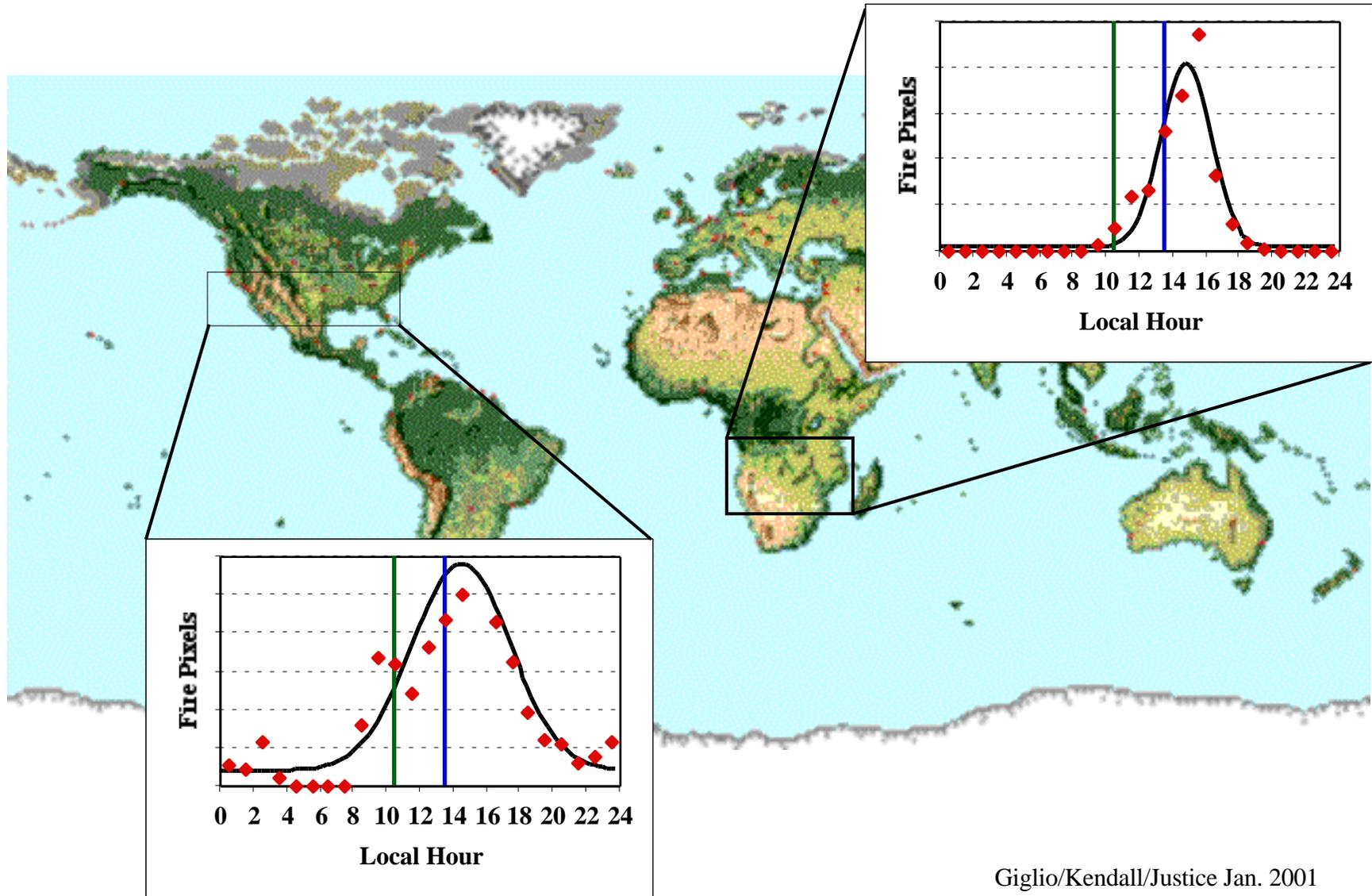


MODIS active fires superimposed
on corrected reflectance

MODIS AQUA Fire

- Four fire observations per-day
- Instrument performance – detector issues?
 - Channels 21,22,31 (Terra Experience)
- Comparison with TERRA (consistent product)
 - Channel 21 not calibrated above 320K
- Will use rapid response for initial beta evaluation
- Will need global test runs on MODAPS (test system ?) – especially for composited fire products
- Will wait for provisional status before operational production and shipping data to the EDC/DAAC

TRMM VIRS-Derived Diurnal Burning Cycle (July)



Giglio/Kendall/Justice Jan. 2001

NPP Fire EDR Status

- Interest in building on the experience gained with MODIS
- Providing continuity for the user community and extending the MODIS data record
- Two components to the VIIRS active fire EDR
 - Detect actively burning fires
 - Retrieve instantaneous temperature and subpixel area of detected fires
- Current instrument design for fire detection has a good 4 micron fire channel with c. 670K saturation, a suboptimal 11 micron channel both at 750m spatial resolution
- Fire is a low priority EDR – although there is significant interest in MODIS fire capabilities from a number of federal and DOD agencies – asking for information on fire intensity and emissions

NPP Fire Issues

- 11 micron channel saturation is too low (340K) for global fire temperature and area retrieval
 - With current instrument design, retrieval cannot be performed for between 1-50% of all fires
- Three proposed fixes rejected
 - Use of NIR/SWIR bands (Results in serious product discontinuities)
 - Giving up a little SNR Margin on I5 band (Air Force Cloud Imager)
 - Increasing range of M15 (Ocean SST)
- Last-hope workaround being evaluated
 - Exploits non-linear folding of sensor response over very hot targets
- Final hardware specification deadlines imminent (within the month)
- If we miss this opportunity we will have to live with it for at least the next decade

EDG Data Ordering Experience

- Not easy to obtain MODIS data, especially time-series (even for the Science Team !)
- Significant fraction of orders fail (20%)
 - highly variable success rate
- Failed orders must be resubmitted by user
 - takes time (≈20 minutes per order)
- Old product versions not properly deleted from archive
- Order Status Request not available
 - “The specified Data Center does not accept Order Status Requests. Please contact them directly to inquire about your order.”
- Distribution and Ease of MODIS Data Access – needs close attention and is the next Tall Pole – requires innovative approaches

Prospects for 2002

- **Active Fire Product Algorithm Improvement - Version 4 Algorithm / ANO20**
- **MODIS Fire User Outreach Workshop (2002) ?**
- **Continued Active Fire Validation (Validated Product by June 2003)**
 - Continue MODIS / ASTER Global Sample Comparison
 - MODIS - GOES/AVHRR/DMSF intercomparisons - collaborations
 - GOFD/Fire - LPV Regional Validation Initiatives (fire and burned area)
 - Southern Africa (SAFNET)
 - SE Asia (SEARIN)
 - Pan Amazon (IBAMA)
 - Australia
 - Russia / Siberia Fire Network
- **Regional Burned Area Test Operational Production Runs and Validation**
 - Tropical – Southern Africa
 - Boreal – Russia / Siberia
- **Regional Pyrogenic Emissions Estimation – prototyping**
 - SAFARI regional emissions calculation and products (SCF)
 - GOFD-Fire Annual Workshop on Emissions Modeling (UMd, July)
- **MODIS Outreach to the Fire User Community through GOFD**
 - USFS and National Interagency Fire Center - MODIS fire locations
 - FTP Real Time Access – fire management agencies
 - Direct Broadcast Fire Code Packaging and Sharing
- **Research > Operations Transition**
 - Rapid Response enhancement – data delivery / enhanced products
 - Fire Rapid Response System Operational Demonstration Activity with NOAA
- **NPP Fire Products**
 - Technical input